DTIC FILE COPY

(2)

211100-3-T

Technical Report

ALP FOPEN SITE DESCRIPTION AND GROUND TRUTH SUMMARY

AD-A224 857

E.S. KASISCHKE
D.M. BEVERSTOCK
N.H.F. FRENCH
L.L. BOURGEAU-CHAVEZ

FEBRUARY 1990

Massachusetts Institute of Technology
Lincoln Laboratory
P.O. Box 73
Lexington, MA 02173-0073

Contract: F19628-85-C-0002

ERIM P.O. Box 8618
Ann Arbor, MI 48107-8618

SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1a REPORT SECURITY CLASSIFICATION Unclassified	1b RESTRICTIVE MARKINGS
2a SECURITY CLASSIFICATION AUTHORITY	3 DISTRIBUTION/AVAILABILITY OF REPORT ~~copies may be obtained from sponsoring~~ agent
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE	
4 PERFORMING ORGANIZATION REPORT NUMBERS(S) 211100-3-T	5 MONITORING ORGANIZATION REPORT NUMBER(S)
6a. NAME OF PERFORMING ORGANIZATION ERIM 6b. OFFICE SYMBOL (if applicable)	7a. NAME OF MONITORING ORGANIZATION MIT/LL
6c. ADDRESS (City, State, and ZIP Code) 1975 Green Road Ann Arbor, MI 48105	7b. ADDRESS (City, State, and ZIP Code) P.O. Box 73 Lexington, MA 02173-0073
8a. NAME OF FUNDING/SPONSORING ORGANIZATION MIT/LL 8b. OFFICE SYMBOL (if applicable)	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER F19628-85-C-0002
8c. ADDRESS (City, State, and ZIP Code) P.O. Box 73 Lexington, MA 02173-0073	10. SOURCE OF FUNDING NUMBERS PROGRAM ELEMENT NO. / PROJECT NO. / TASK NO / WORK UNIT ACCESSION NO

11. TITLE (Include Security Classification)

ALP FOPEN Site Description and Ground Truth Summary

12. PERSONAL AUTHOR(S)

E. Kasischke, D. Beverstock, N. French, and L. Chavez

13a. TYPE OF REPORT	13b TIME COVERED	14. DATE OF REPORT (Year, Month, Day)	15. PAGE COUNT
Technical	FROM 10/88 TO 2/90	February 1990	375

16. SUPPLEMENTARY NOTATION

17 COSATI CODES			18. SUBJECT TERMS *(Continue on reverse if necessary and identify by block number)*
FIELD	GROUP	SUB-GROUP	Foliage penetration experiment; tree characteristics, dielectric measurements.

19 ABSTRACT *(Continue on reverse if necessary and identify by block number)*

This report summarizes ground truth data collected during the 1988 P-3 SAR data mission over Camp Ripley, Minnesota. Specifically, it deals with test sites established to more clearly understand the phenomenology associated with radar detection of targets obscured by vegetation. The test sites consisted of trihedral corner reflectors deployed in six different tree stands. Ground truth collected during this activity includes: (1) ground photography of each site; (2) climatic data for the experimental period; (3) measurement of tree density, diameter, height and placement relative to the target for each site; (4) for some cases, measurement of branch and needle biomass, diameter, angles and length; (5) allometric equations describing the destribution of above ground biomass for the various tree species; and (6) dielectric measurements of the two major tree species found within the test area.

20 DISTRIBUTION/AVAILABILITY OF ABSTRACT ☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT ☐ DTIC USERS	21. ABSTRACT SECURITY CLASSIFICATION unclassified
22a. NAME OF RESPONSIBLE INDIVIDUAL E. Kasischke	22b. TELEPHONE (Include Area Code) / 22c. OFFICE SYMBOL

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF FIGURES (continued)

LIST OF FIGURES (continued)

LIST OF FIGURES (continued)

LIST OF FIGURES (continued)

LIST OF FIGURES (concluded)

LIST OF TABLES

LIST OF TABLES (continued)

ERIM

ALP FOPEN SITE DESCRIPTIONS AND GROUND TRUTH SUMMARY

1.0 INTRODUCTION

During the fall of 1988, an extensive set of multifrequency (1.25, 5.3 and 9.35 GHz), and in some cases polarimetric airborne SAR imagery was collected over Camp Ripley, Minnesota, by the ERIM/NADC P-3 SAR System (see, e.g., Sullivan et al., 1989). This data collection was sponsored by the U.S. Air Force Wright-Patterson's Avionics Laboratory (AFWAL) and the Massachusetts Institute of Technology's Lincoln Laboratory (MIT/LL). The acronym for this data collection was ALP, which stands for AFWAL/LL/P-3.

The primary objective for this data collection was to collect digital SAR data to: (1) evaluate the detectability of strategic targets as a function of radar frequency, polarization, and degree of obscuration; and (2) begin to quantify the effects of foliage on detection of targets. To address this latter issue, a set of FOPEN test sites were established at Camp Ripley, Minnesota. A set of precision trihedral corner reflectors were placed within these test sites in order to provide calibrated references for quantitatively evaluating the effects of tree canopies on the detection of targets. In addition, a set of ground-truth data were collected to characterize the canopies under which the targets were placed. An initial set of measurements of these targets has been made (Lewis et al., 1989). These ground-truth measurements will eventually be used as inputs into theoretical microwave scattering models which predict the effects of the canopy on target detection. The predictions from these models will then be compared to the outputs from theoretical scattering models (see, e.g., Kasischke et al., 1989; Dobson et al., 1989).

The purpose of this report is to document and summarize the ground-truth data sets associated with the ALP SAR data collection. Section

2 presents the layouts of the six different FOPEN test stands, summarizes the ground photographs which were collected, and discusses the climatic conditions present during the ALP mission. Section 3 summarizes the stand and tree geometry data for each site within the six different stands. Finally, Section 4 presents dielectric measurements which were made for the different tree types and soil and litter conditions present in the FOPEN test stands.

There are several appendices to this report. Appendix A presents copies of all the ground truth photographs collected for each of the FOPEN sites. Appendix B contains a listing of all tree ground-truth measurements collected as part of this experiment. Finally, Appendix C contains a listing of all dielectric measurments made for the aspen and jack pine trees and the soil and litter layers.

2.0
TEST SITE DESCRIPTION

To aid in analysis of the effects of tree canopies on target detection, a set of calibrated radar targets were deployed at six different sites in Camp Ripley. These six sites represented two tree classes with three tree densities per class. The locations of the test sites are presented in Figure 1 and summarized below:

JS - Sparse Jack Pine
JM - Medium Jack Pine
JD - Dense Jack Pine
AS - Sparse Aspen
AM - Medium Aspen
AD - Dense Aspen

In this section, we present: (1) the basic layout of the targets during the ALP data collection flights; (2) surface and aerial photography of the different test sites; and (3) the climatological conditions during the SAR flights. The primary P-3 SAR missions were flown on five different dates, as summarized in Table 1. There were flights on 19 and 20 October; however, only a limited amount of data were collected on these dates because of a malfunction in the antenna positioner controller (Sullivan et al., 1989).

2.1 TARGET LAYOUTS AND AERIAL PHOTOGRAPHS

Figure 1 presents the locations of the six different FOPEN test stands. Figures 2 through 11 present schematic diagrams and aerial photographs of these stands. Note, with the exception of the medium and dense aspen sites (which were collected in the spring of 1988 prior to leaf flushing), the aerial photographs were collected during the summer of 1988, when leaves were present. A minimum amount of leaf cover was present on the deciduous trees at the time of the SAR data collections.

TABLE 1
SUMMARY OF FLIGHT DATES AND TIMES FOR
ALP DATA COLLECTIONS

DATE	START TIME (CST)	END TIME (CST)
14 OCT 1988	09:56	13:59
15 OCT 1988	11:39	15:48
17 OCT 1988	07:48	12:22
23 OCT 1988	08:34	12:53
24 OCT 1988	08:36	09:34

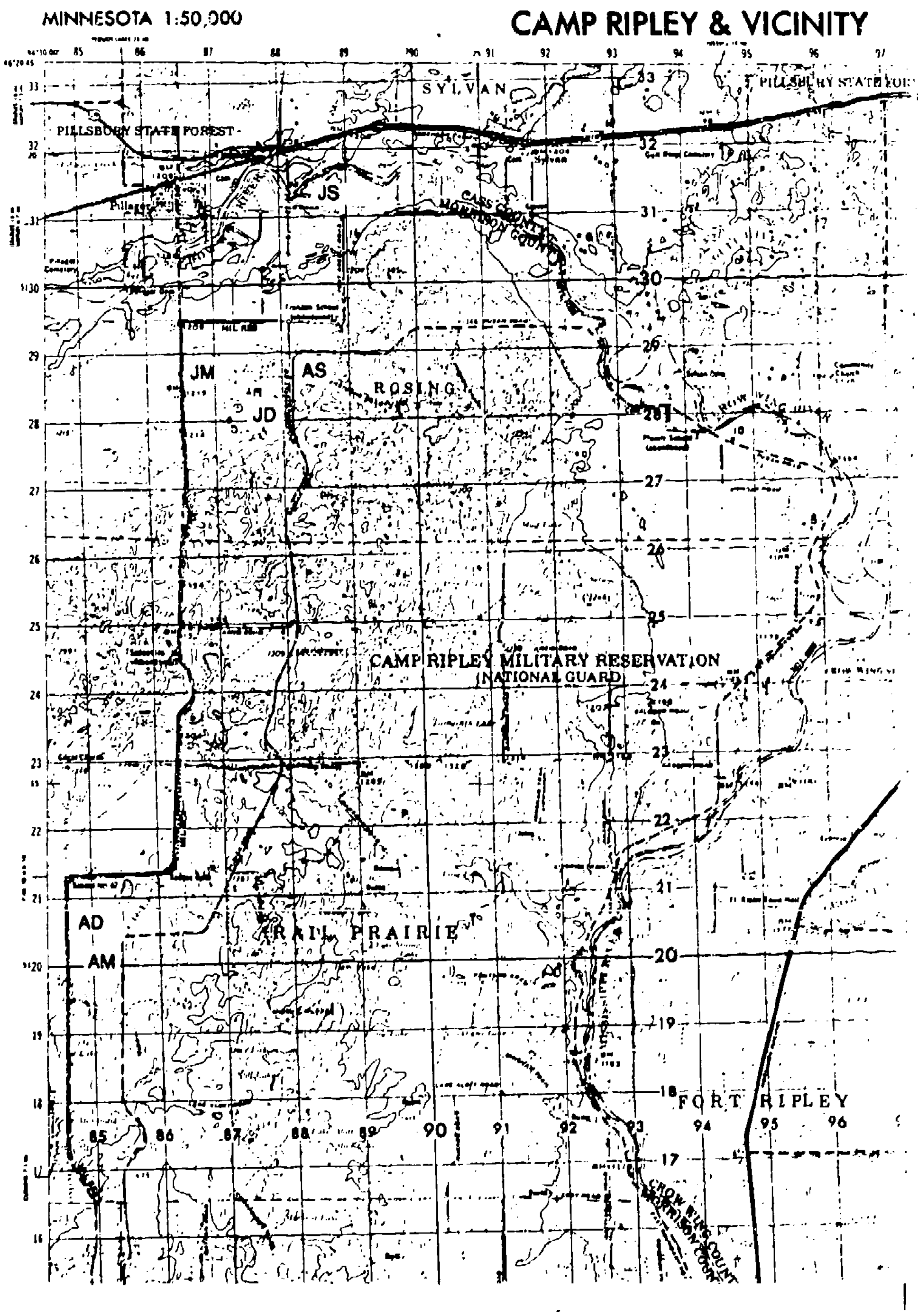


Figure 1. Location of FOPEN Test Sites at Camp Ripley

88-22348

REFLECTORS

FLIGHTS

Site	1, 2	4
J11	L-ARC	L-ARC
J12	89 cm T	120 cm Tr
J13	120 cm T	85 cm Tr
J14	120 cm T	120 cm T
J15	106 cm GT	106 cm GT
J16	106 cm GT	106 cm GT

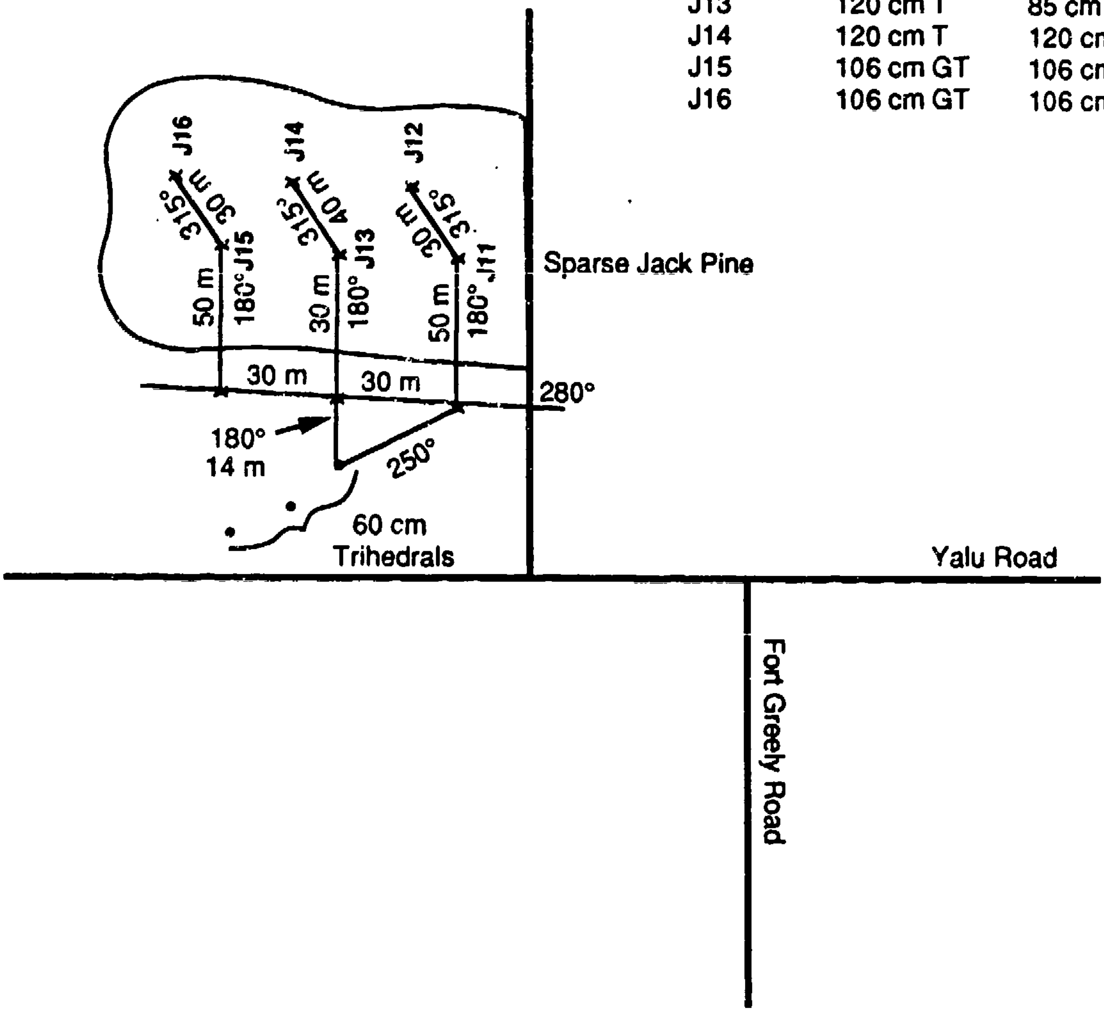


Figure 2. Target Layout Within Sparse Jack Pine Test Site

Aerial Photograph of Site JS - Sparse Jack Pine

Figure 3. Aerial Photograph of Site JS - Sparse Jack Pine

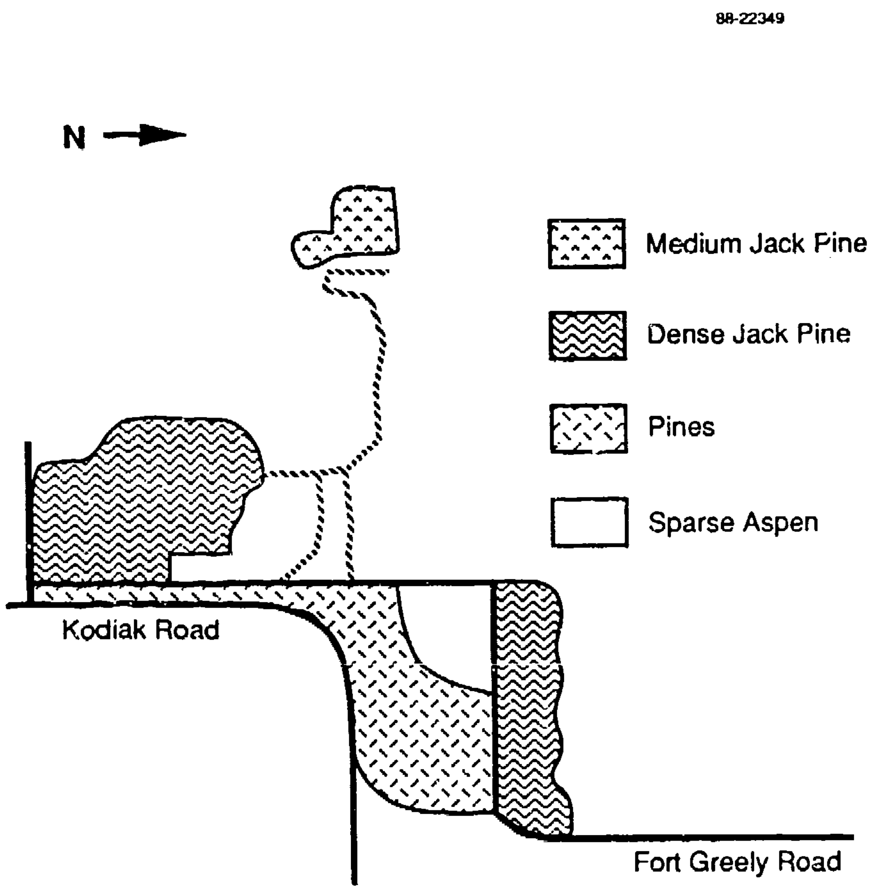


Figure 4. Location of Medium and Dense Jack Pine and Sparse Aspen FOPEN Test Sites Along Fort Greely Road

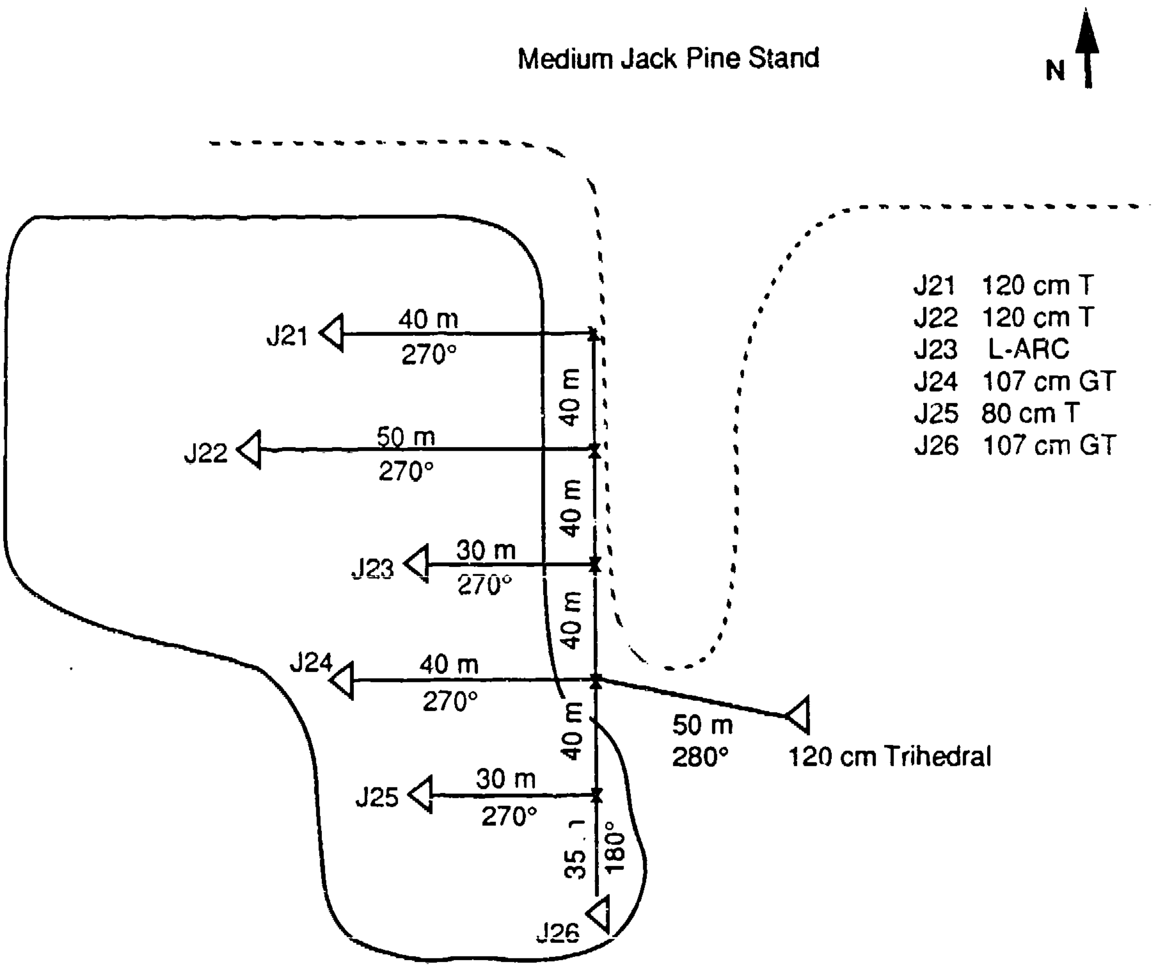


Figure 5. Target Layout Within Medium Jack Pine Test Site

Aerial Photograph of Sites JM and JD - Medium and Dense Jack Pine

Figure 6. Aerial Photograph of Sites JM and JD - Medium and Dense Jack Pine

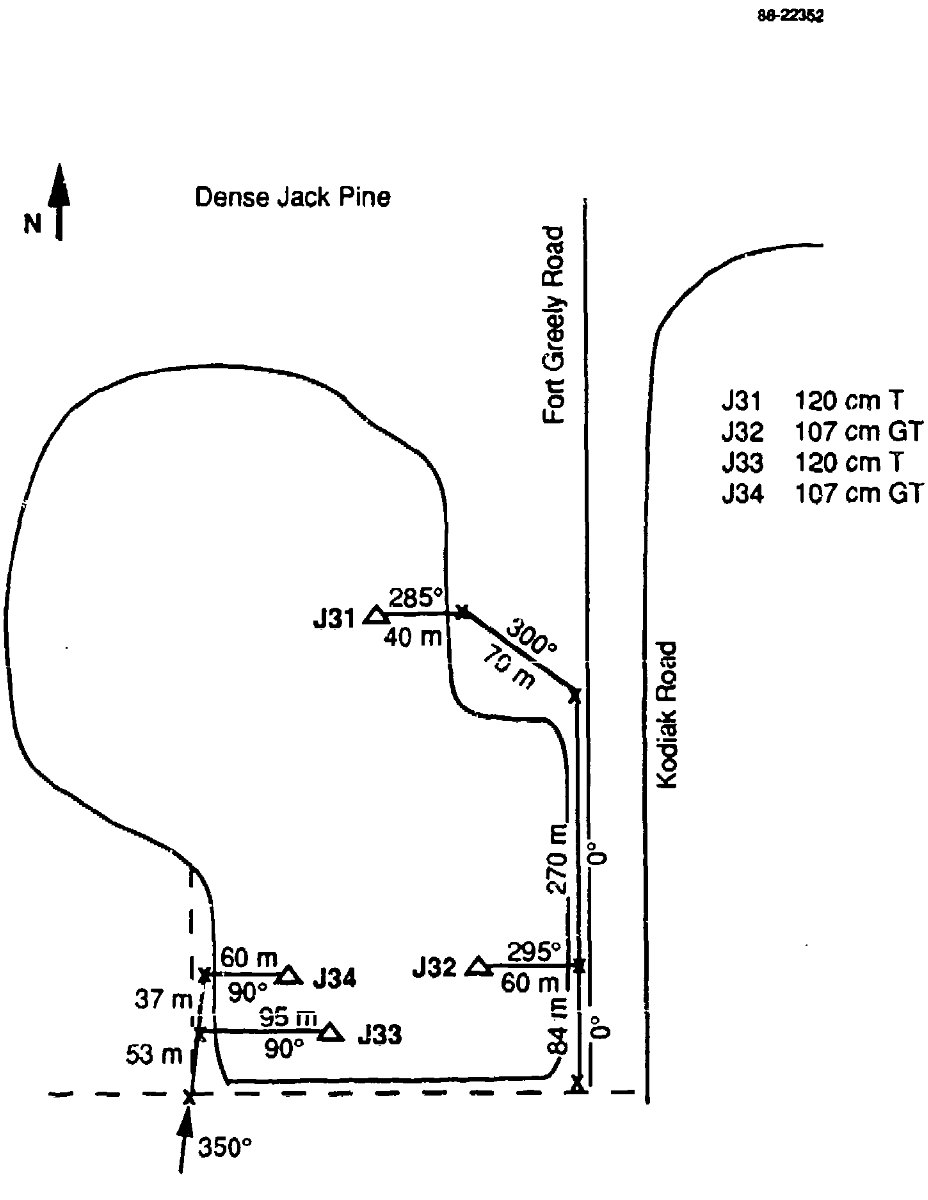


Figure 7. Target Layout Within Dense Jack Pine Test Site

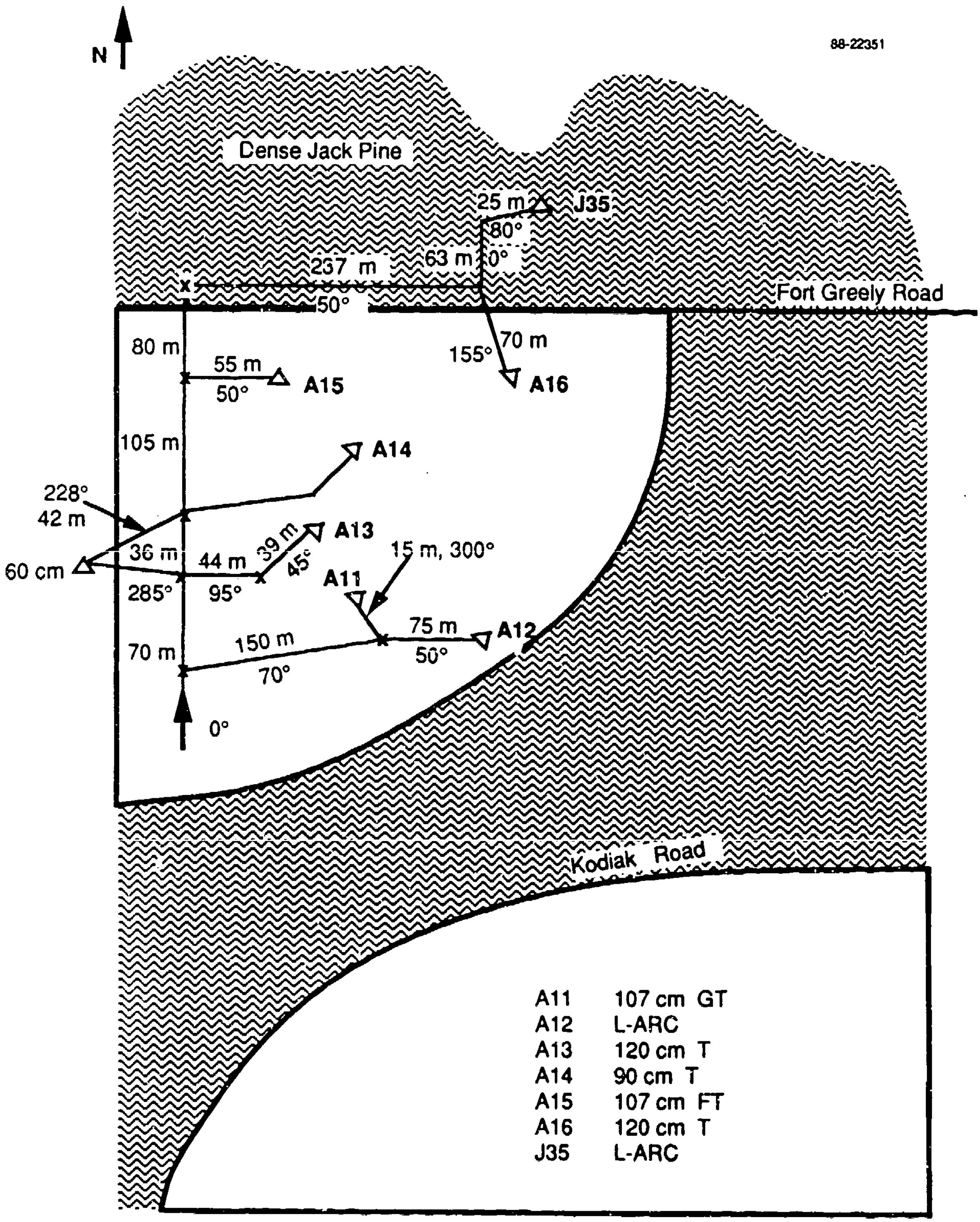


Figure 8. Target Layout Within Sparse Aspen Test Site

Figure 9. Aerial Photograph of Site AS - Sparse Aspen

88-22353 R1

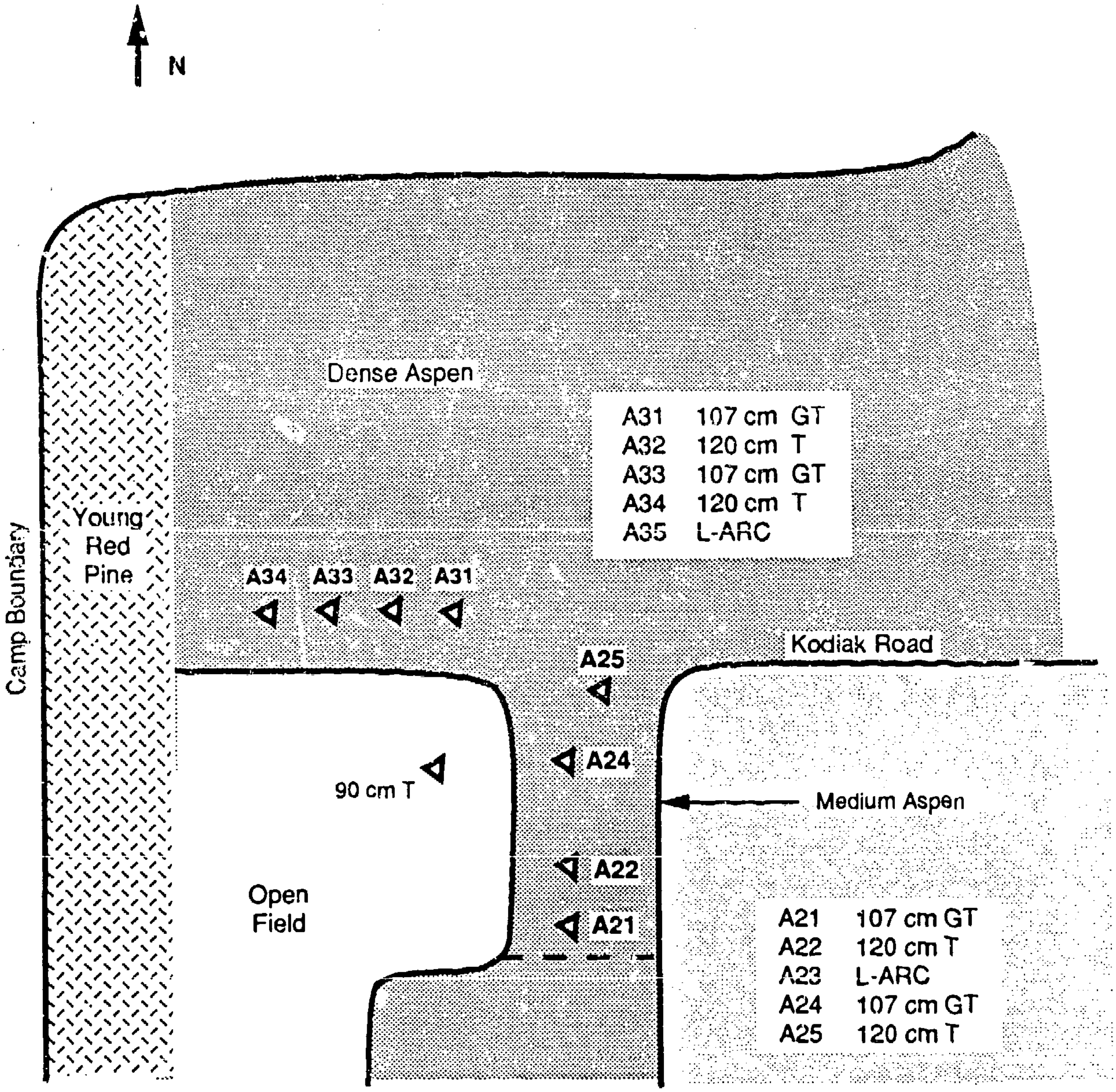


Figure 10. Target Layout Within Medium and Dense Aspen Test Sites

Figure 11. Aerial Photograph of Sites AM and AD - Medium and Dense Aspen

2.2 STAND PHOTOGRAPHS

To aid in the interpretation of the degree of obscuration being experienced by an individual target, surface photography was collected for each target. This photography was collected on three different dates: (1) during October 1988, during the P-3 SAR data collections; (2) in May of 1989, during a second visit to the site; and (3) in early November of 1989, during a third visit to this site.

Several different sets of photographs were collected at each site:

1. From the location of the bottom rear of the corner reflector, a view towards the east, with the camera pointed horizontal, and 20° to 40° above the horizon. Recall, the SAR was "looking" towards the west during most of the data collections. Thus, these photographs capture one view of the trees through which the radar waves passed;

2. A horizontal view of the target location looking from the north, west and east in order to capture the general ground cover conditions, as well as the closeness of the trees to the target; and

3. For the medium and dense aspen stands, a view towards 304° which corresponds to the look direction used during the clutter passes.

The surface photographs are presented in Appendix A to this report.

2.3 CLIMATOLOGICAL DATA

The weather conditions at the time of a SAR data collection can have a significant impact on the radar signatures from a forest. These potential effects are:

1. Rainfall prior or during data collection will increase the soil and litter moisture, which increases the dielectric constant of the soil/litter layer. An increase in dielectric constant of this layer may lead to an increase in the radar scattering coefficient of the forest scene due to an increase in ground-trunk scattering.

2. Rainfall during data collection will result in a layer of water coating the various components of the tree canopy, and alter the radar signature from the canopy.

3. Similarily, dew settling on a tree canopy will have the same results as a light rainfall.

4. When temperatures fall below freezing, the fluids within a tree often change states from a liquid to a solid form. This change of state has been shown to result in a significant lowering of the dielectric constant of the tree bole (Kasischke, 1989; Cimino et al., 1990), which also affects the radar scattering from the tree canopy.

5. Finally, during sunny, warm conditions, photosynthesis and respiration by the leaves within the canopy can result in a diurnal change in the dielectric constant of the tree fluids, and have been shown to result in diurnal changes in the radar scattering coefficient from tree canopies (Dobson et al, 1988; 1989).

In this section, we will first present a summary of a variety of climatic data which have been archived by the National Climatic Data Center in Asheville, North Carolina. Then, based on these records as well as observations recorded at the time of the radar overflights, we will discuss the climatic conditions for each P-3 SAR mission.

2.3.1 Summary of Climatic Data

Climatic records reviewed under this activity contained the following data: (1) precipitation; (2) minimum and maximum daily temperature; and (3) dew point relative to temperature. These parameters were compiled for eight weather stations surrounding Camp Ripley for October of 1988. In this section, the climate data for each flight date, including those days (19 and 20 October) when flights were shortened due to mechanical difficulties, are presented. The locations for the weather stations are shown in Figure 12. These stations include: Brainerd, Fort Ripley, Little Falls, Saint Cloud, Alexandria, Long Prairie, Wadena, and Ottertail.

Table 2 summarizes the daily maximum and minimum temperatures and daily precipitation for each weather station for October of 1988. Note the Fort Ripley weather station did not report daily temperatures. Table 3 summarizes the hourly temperature, dewpoint, and precipitation for the St. Cloud weather station. Table 4 summarizes the hourly temperature and dewpoint for the Brainerd weather station.

Figure 13 presents the average minimum and maximum daily temperatures for the seven weather stations which reported daily temperatures. From this graph, it appears that the temperature was below freezing on 19, 20, and 24 October. Figure 14 presents the average hourly temperatures (for the Brainerd and St. Cloud weather stations) for these three flight dates. This graph shows that by the time the flight began on 19 October (2:48pm CST) the temperature was above freezing and remained as such throughout the flight (ending 3:36pm CST). The same was true for the flight of 20 October. For the flight of 24 October the temperature appeared to be below freezing at the start of the flight (8:36am CST) and remained below freezing to the end of the flight (9:42am CST).

Figure 15 presents average daily precipitation, which was calculated using all of the weather stations but Fort Ripley, and Fort Ripley daily precipitation for the month of October 1988. It appears to have been raining during the flights of 17, 19, 20, and 23 October according to

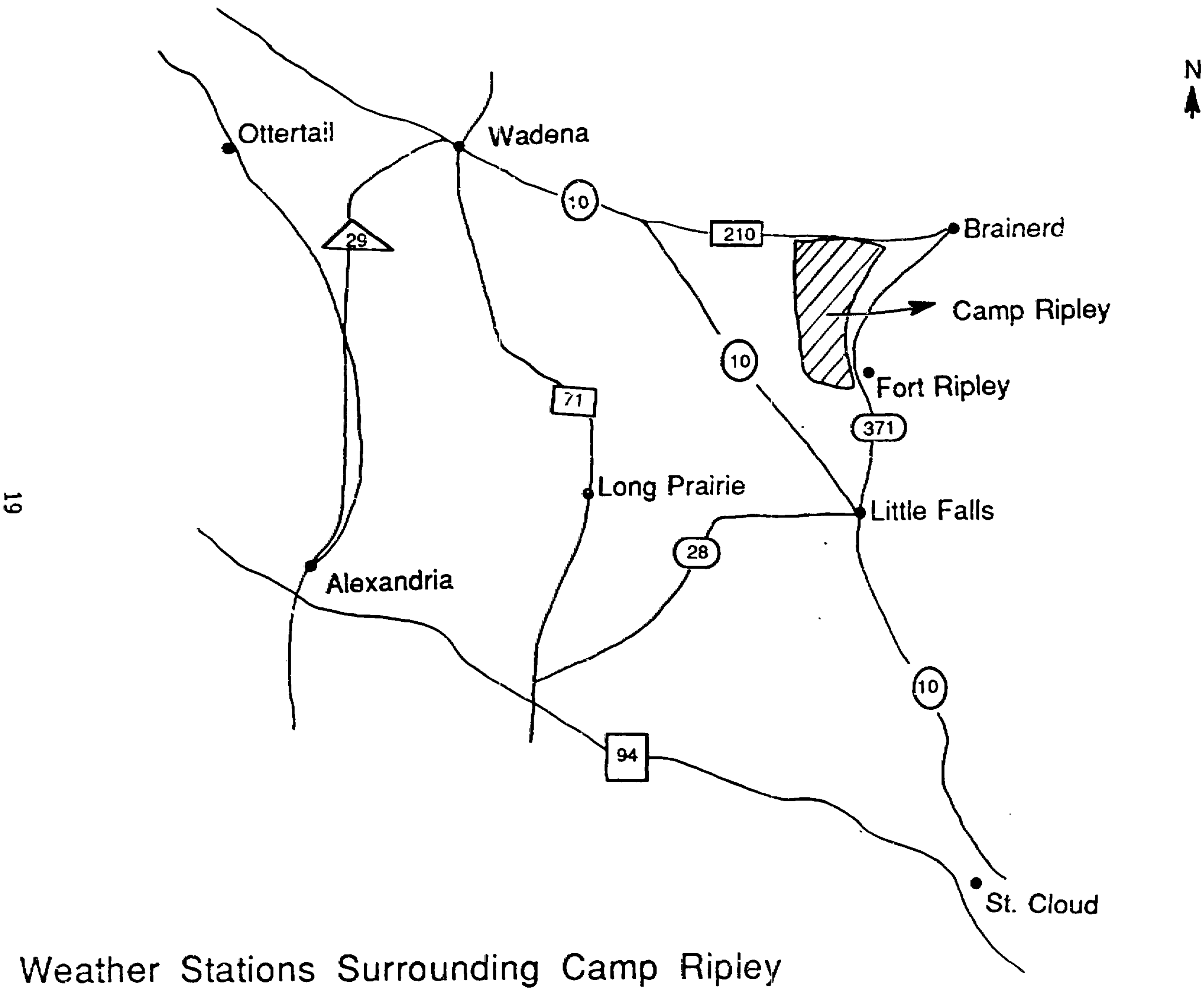


Figure 12. Locations of Weather Stations Around Camp Ripley, Minnesota

TABLE 2

DAILY MINIMUM (TMIN) AND MAXIMUM (TMAX) TEMPERATURES AND PRECIPITATION (PPT) FOR THE MONTH OF OCTOBER 1988 FOR THE MINNESOTA WEATHER STATIONS

OCTOBER 1988 WEATHER RECORDS

	WADENA			OTTERTAIL		
DATE	TMAX(C)	TMIN(C)	PPT(cm)	TMAX(C)	TMIN(C)	PPT(cm)
1	15	7	0	18	9	0
2	18	2	0	16	3	0
3	13	2	0	8	2	.08
4	8	-4	0	7	-3	0
5	9	-4	0	13	-2	0
6	12	-4	0	15	2	0
7	15	-1	0	18	7	0
8	18	1	0	20	3	0
9	20	1	0	21	6	0
10	22	2	0	19	7	0
11	13	-2	0	12	-1	0
12	8	-6	0	13	-3	0
13	12	-6	0	18	3	0
14	19	1	0	26	7	0
15	26	2	0	23	9	0
16	22	8	0	19	8	0
17	14	3	.05	12	3	.58
18	9	-1	.56	7	3	.33
19	7	-2	.43	10	-1	.13
20	10	-1	0	9	1	.73
21	6	2	.78	7	3	0
22	7	-4	0	11	-2	0
23	11	-3	0	9	-1	.15
24	1	-6	0	6	-4	0
25	2	-6	0	3	-5	0
26	1	-9	0	6	-8	0
27	6	-8	0	5	-1	.48
28	2	-11	.56	1	-8	0
29	-3	-12	0	2	-11	0
30	1	-11	0	7	-7	0
31	7	-6	0	9	3	0

TABLE 2 (continued)

DAILY MINIMUM (TMIN) AND MAXIMUM (TMAX) TEMPERATURES
AND PRECIPITATION (PPT) FOR THE MONTH OF OCTOBER 1988
FOR THE MINNESOTA WEATHER STATIONS

OCTOBER 1988 WEATHER RECORDS

	SAINT CLOUD			LITTLE FALLS		
DATE	TMAX(C)	TMIN(C)	PPT(cm)	TMAX(C)	TMIN(C)	PPT(cm)
1	19	7	0	19	9	0
2	15	2	0	18	2	0
3	11	-1	T	18	2	.25
4	9	-2	0	9	-1	0
5	12	-5	0	12	-4	0
6	15	-2	0	15	0	0
7	17	-1	0	18	0	0
8	21	0	0	20	1	0
9	22	0	0	22	3	0
10	16	5	0	21	8	0
11	10	-2	0	13	-2	0
12	12	-6	0	12	-6	0
13	19	-2	0	19	1	0
14	25	1	0	26	2	0
15	22	4	0	24	6	0
16	17	4	0	17	9	0
17	8	0	.53	12	4	.66
18	12	-4	T	9	-1	.05
19	13	-5	0	11	-1	0
20	6	-4	.83	9	-3	.81
21	9	-2	0	9	3	.10
22	12	-6	0	11	-4	T
23	9	0	.03	10	0	0
24	6	-3	0	6	-4	0
25	3	-5	0	3	-6	0
26	7	-7	0	6	-7	0
27	8	-3	.33	5	0	T
28	0	-8	T	1	-6	0
29	2	-10	0	2	-11	0
30	7	-12	0	6	-9	0
31	12	-3	T	9	-5	0

TABLE 2 (continued)

DAILY MINIMUM (TMIN) AND MAXIMUM (TMAX) TEMPERATURES
AND PRECIPITATION (PPT) FOR THE MONTH OF OCTOBER 1988
FOR THE MINNESOTA WEATHER STATIONS

OCTOBER 1988 WEATHER RECORDS

	ALEXANDRIA			LONG PRAIRIE		
DATE	TMAX(C)	TMIN(C)	PPT(cm)	TMAX(C)	TMIN(C)	PPT(cm)
1	18	8	0	18	9	0
2	14	3	0	17	2	0
3	12	3	0	13	1	.08
4	11	-2	0	9	-2	0
5	12	-1	0	12	-4	0
6	15	1	0	15	-1	0
7	17	3	0	18	3	0
8	19	3	0	21	2	0
9	22	5	0	22	2	0
10	13	7	0	21	7	0
11	10	0	0	12	-1	0
12	12	-3	0	6	-5	0
13	19	1	0	19	3	0
14	25	5	0	26	3	0
15	22	7	.03	25	6	0
16	15	7	0	21	10	.13
17	9	2	.58	15	4	.08
18	9	-1	.05	9	0	.33
19	9	-2	0	12	-1	0
20	7	1	.51	9	-1	0
21	8	1	.03	8	3	.71
22	11	-2	0	11	-4	0
23	8	-1	.03	11	1	0
24	4	-4	0	4	-4	0
25	3	-5	0	3	-5	0
26	7	-8	0	6	-8	0
27	4	-4	.25	6	0	0
28	-2	-8	0	0	-7	.35
29	3	-8	0	2	-11	0
30	8	-8	0	7	-9	0
31	10	2	0	9	1	0

TABLE 2 (concluded)

DAILY MINIMUM (TMIN) AND MAXIMUM (TMAX) TEMPERATURES AND PRECIPITATION (PPT) FOR THE MONTH OF OCTOBER 1988 FOR THE MINNESOTA WEATHER STATIONS

OCTOBER 1988 WEATHER RECORDS

	BRAINERD			FORT RIPLEY
DATE	TMAX(C)	TMIN(C)	PPT(cm)	PPT(cm)
1	19	8	0	0
2	14	-1	0	0
3	10	-1	.05	.05
4	9	-3	0	0
5	12	-4	0	0
6	16	-3	0	0
7	19	1	0	0
8	21	0	0	0
9	22	1	0	0
10	14	6	0	0
11	9	-3	0	0
12	12	-6	0	0
13	19	0	0	0
14	26	1	0	0
15	21	4	0	0
16	16	2	.23	.13
17	8	-1	.13	.25
18	7	-2	.40	0
19	12	-4	.10	0
20	6	-3	0	0
21	9	-3	.83	1.21
22	11	-5	0	0
23	8	-1	.08	0
24	4	-3	T	0
25	0	-4	0	0
26	6	-6	0	0
27	4	-3	0	0
28	1	-7	.46	.10
29	1	-10	0	0
30	7	-11	0	0
31	9	-3	T	0

TABLE 3

ST. CLOUD HOURLY TEMPERATURE (TEMP), DEWPOINT (DPT), AND PRECIPITATION (PPT) FOR EACH ALP FLIGHT DATE
[Time is in Central Standard Time (CST)]

SAINT CLOUD HOURLY WEATHER CONDITIONS

	OCT 14, 1988			OCT 15, 1988		
CST	TEMP(C)	DPT(C)	PPT(cm)	TEMP(C)	DPT(C)	PPT(cm)
5am	2	1	0	5	5	0
6am	1	0	0	4	4	0
7am	1	0	0	5	5	0
8am	6	3	0	8	7	0
9am	11	6	0	11	8	0
10am	15	7	0	14	9	0
11am	18	8	0	18	9	0
12pm	21	8	0	19	10	0
1pm	22	8	0	21	9	0
2pm	24	9	0	22	10	0
3pm	24	9	0	21	10	0
4pm	24	9	0	21	10	0
5pm	23	9	0	19	10	0
6pm	18	9	0	17	11	0

	OCT 17, 1988			OCT 19, 1988		
CST	TEMP(C)	DPT(C)	PPT(cm)	TEMP(C)	DPT(C)	PPT(cm)
5am	6	5	.15	-4	-5	0
6am	6	6	.03	-4	-5	0
7am	7	6	T	-5	-6	0
8am	6	5	.05	-1	-1	0
9am	6	5	.10	4	-1	0
10am	6	5	.05	7	-1	0
11am	6	5	.08	9	-1	0
12pm	6	6	.05	12	-1	0
1pm	7	4	.03	13	-4	0
2pm	7	4	0	13	-4	0
3pm	7	3	0	12	-4	0
4pm	7	2	0	11	-4	0
5pm	7	1	0	9	-4	0
6pm	6	0	0	7	-3	0

TABLE 3 (concluded)

ST. CLOUD HOURLY TEMPERATURE (TEMP), DEWPOINT (DPT), AND PRECIPITATION (PPT) FOR EACH FLIGHT ALP DATE
[Time is in Central Standard Time (CST)]

SAINT CLOUD HOURLY WEATHER CONDITIONS

	OCT 20, 1988			OCT 23, 1988		
CST	TEMP(C)	DPT(C)	PPT(cm)	TEMP(C)	DPT(C)	PPT(cm)
5am	1	-1	0	3	-3	0
6am	3	0	0	3	-4	0
7am	3	0	T	2	-4	0
8am	5	-2	.03	2	-4	0
9am	4	-2	.03	2	-3	T
10am	5	0	.03	1	-1	T
11am	5	-2	.15	2	-1	T
12pm	6	-1	.23	2	-1	.03
1pm	6	-1	.13	3	-2	T
2pm	6	5	.13	3	-2	0
3pm	6	5	.13	3	-3	0
4pm	6	4	T	2	-4	0
5pm	6	5	T	2	-5	0
6pm	6	6	T	1	-6	0

OCT 24, 1988

CST	TEMP(C)	DPT(C)	PPT(cm)
5am	-3	-7	0
6am	-3	-7	0
7am	-3	-7	0
8am	-3	-7	0
9am	-2	-6	0
10am	0	-7	0
11am	2	-7	0
12pm	3	-7	0
1pm	4	-7	0
2pm	5	-7	0
3pm	6	-7	0
4pm	4	-7	0
5pm	3	-7	0
6pm	2	-6	0

TABLE 4

BRAINERD HOURLY TEMPERATURE (TEMP) AND DEWPOINT (DPT)
FOR EACH ALP FLIGHT DATE
[Time is in Central Standard Time (CST)]

BRAINERD HOURLY WEATHER CONDITIONS

	OCT 14, 1988		OCT 15, 1988	
CST	TEMP(C)	DPT(C)	TEMP(C)	DPT(C)
5am	6	3	7	6
6am	4	2	6	6
7am	3	2	8	6
8am	5	3	9	7
9am	9	5	11	7
10am	13	6	14	9
11am	17	9	18	10
12pm	20	11	19	11
1pm	23	13	19	12
2pm	23	12	20	12
3pm	24	21	19	12
4pm	24	21	19	14
5pm	21	17	18	17
6pm	19	14	16	14

	OCT 17, 1988		OCT 19, 1988	
CST	TEMP(C)	DPT(C)	TEMP(C)	DPT(C)
5am	5	4	-1	-1
6am	5	4	-2	-2
7am	4	4	-3	-3
8am	4	3	-1	-2
9am	3	3	2	-3
10am	4	4	3	2
11am	5	4	6	2
12pm	6	5	8	2
1pm	7	4	10	2
2pm	7	3	11	-1
3pm	8	2		
4pm	7	2	11	6
5pm	8	1	9	6
6pm	7	1	6	3

TABLE 4 (concluded)

BRAINERD HOURLY TEMPERATURE (TEMP) AND DEWPOINT (DPT)
FOR EACH ALP FLIGHT DATE
[Time is in Central Standard Time (CST)]

BRAINERD HOURLY WEATHER CONDITIONS

	OCT 20, 1988		OCT 23, 1988	
CST	TEMP(C)	DPT(C)	TEMP(C)	DPT(C)
5am	-1	-1	3	2
6am	2	-3		
7am	2	2	1	-1
8am	3	0	1	0
9am	3	2		
10am	3	3	1	1
11am	3	3	2	1
12pm	4	4	2	1
1pm	4	4	2	1
2pm	4	4	2	2
3pm	4	4	2	1
4pm	4	4	1	1
5pm	5	5	1	1
6pm	5	5	0	-1

	OCT 24, 1988	
CST	TEMP(C)	DPT(C)
5am	-3	-7
6am	-3	-6
7am	-3	-5
8am	-3	-6
9am	-2	-4
10am	-2	-5
11am	-1	-4
12pm	0	-2
1pm	2	-1
2pm	2	2
3pm	4	2
4pm	3	1
5pm	1	0
6pm	0	-1

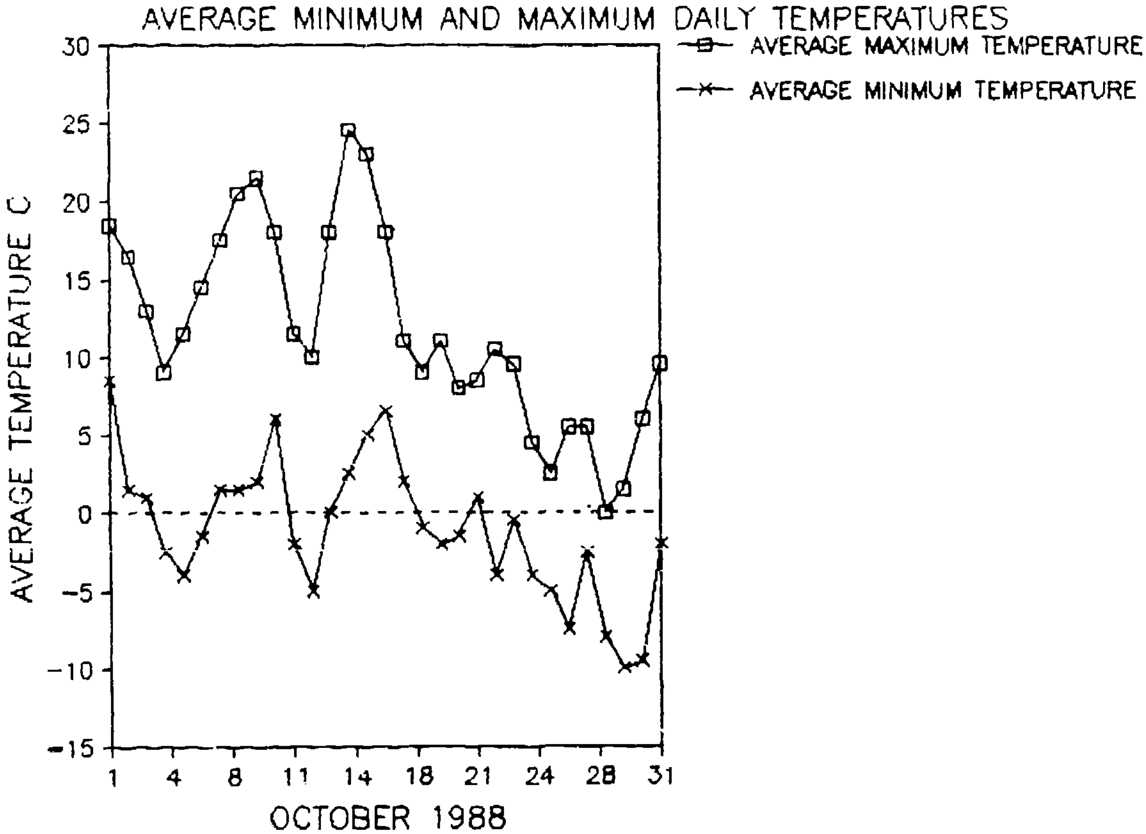


Figure 13. Average Minimum and Maximum Daily Temperatures for all Weather Stations

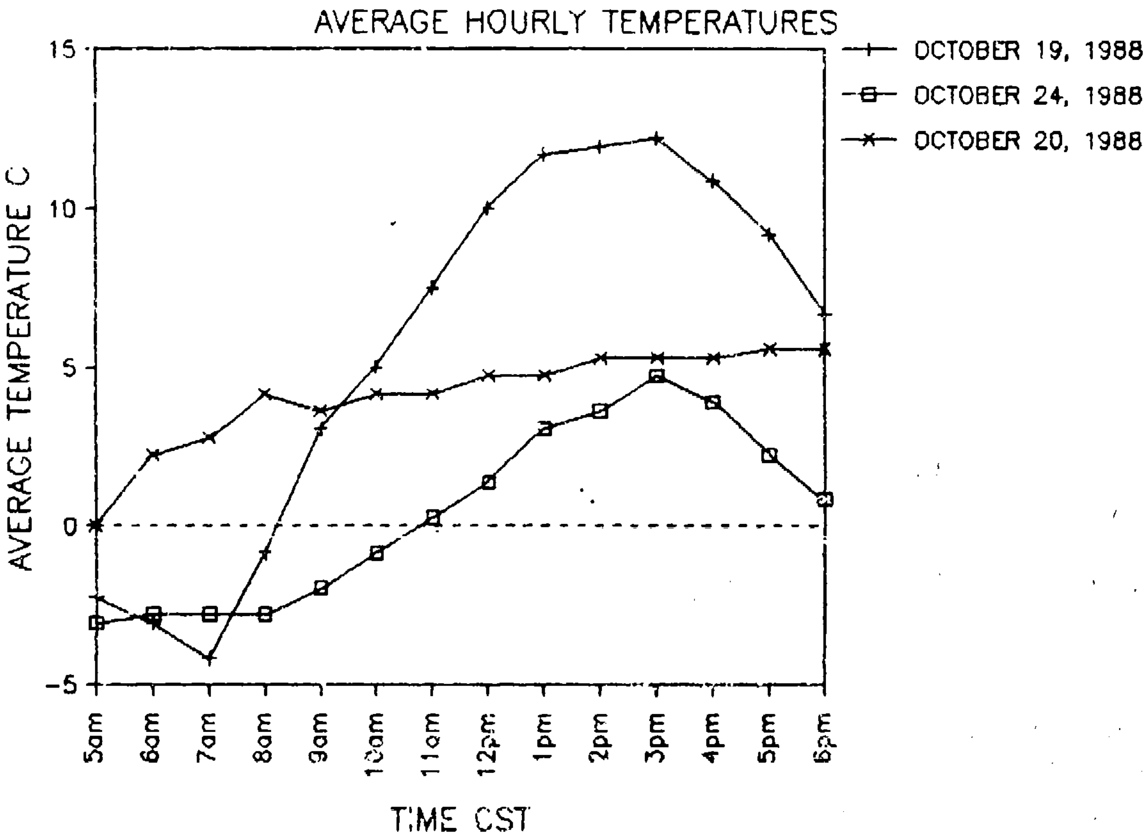


Figure 14. Average (for Brainerd and St Cloud) Minimum and Maximum Hourly Temperatures

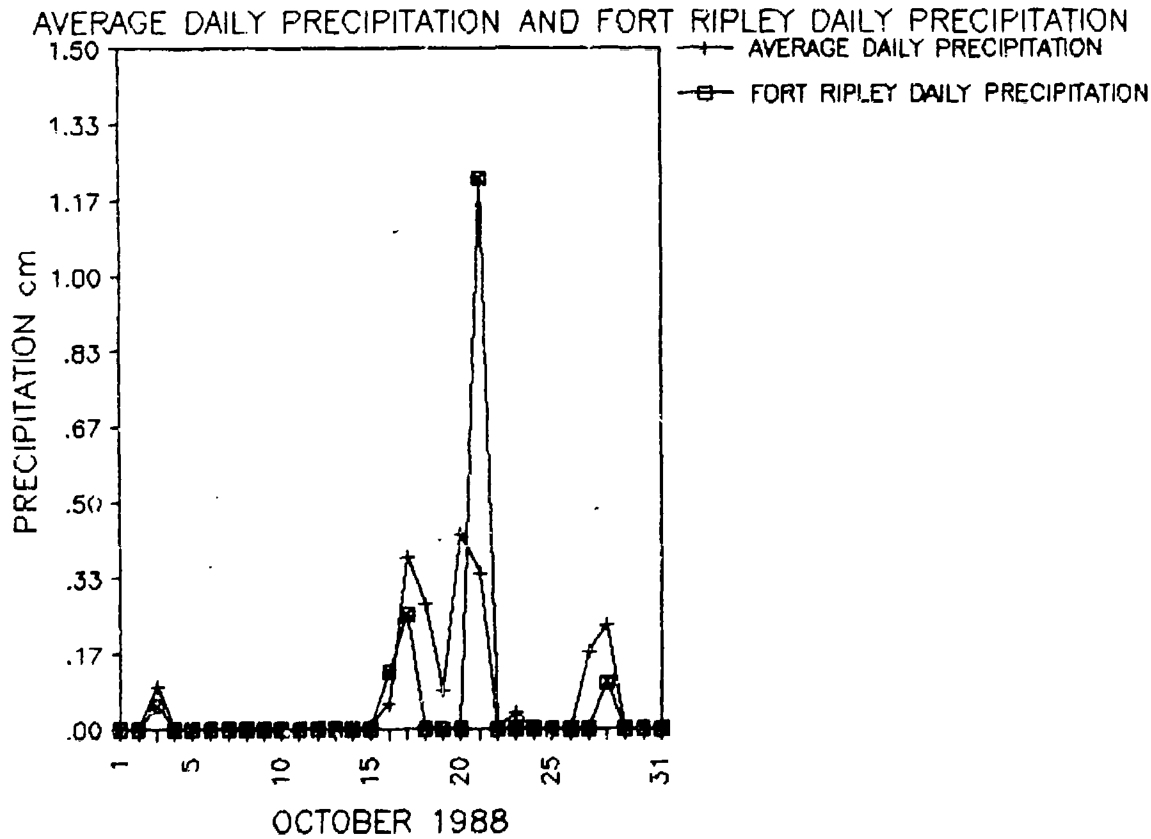


Figure 15. Average Daily Precipitation for all Weather Stations

the average daily precipitation data and only on the flight of 17 October according to the Fort Ripley data.

The cummulative hourly precipitation data for St. Cloud for three of the four flight dates are presented in Figure 16. For the fourth flight of 19 October, St. Cloud did not report any precipitation. From this graph it appears to have been raining steadily throughout the flight of 17 October (7:48 a.m. to 12:22 p.m. CST). For the flight of 20 October, it seems to have been raining heavily. For the flight of 23 October (8:34 a.m. to 12:53 p.m. CST) it appears to have been dry until 11:00am when there was a short light rain.

Figure 17 presents the average three day cummulative precipitation for all but the Fort Ripley weather station and the three day cummulative precipitation for Fort Ripley. From this graph wet soil conditions appear to have been present for the flights of 17, 19, 20, 23, and 24 October according to the average three day cummulative data and for the 17, 19, and 23 October according to the Fort Ripley data.

Figure 18 presents hourly dewpoint and temperatures for St. Cloud and Brainerd for each flight date. According to these graphs dew or frost may have been present on 15, 17 and 19 October.

2.3.2 Mission Climate Summary

For the flight of 14 October 1988, there was no measureable precipitation during the previous week, and there was no discernable dew present at the time of the P-3 SAR data collections. Because of the relatively sandy soil conditions present at the FOPEN test sites, the soil/litter moisture was most likely low, and no surface moisture was present within the canopy. It was mostly sunny on this date, with warm temperatures. Thus, there may have been some diurnal variation in the trunk dielectric constant in the jack pine stands, but because of the absence of any photosynthetically-active pigments in the deciduous leaf tissue, there was most likely no diurnal variation in the aspen stands.

The climatic conditions for the flight of 15 October 1988 were identical to those for the flight of the 14th.

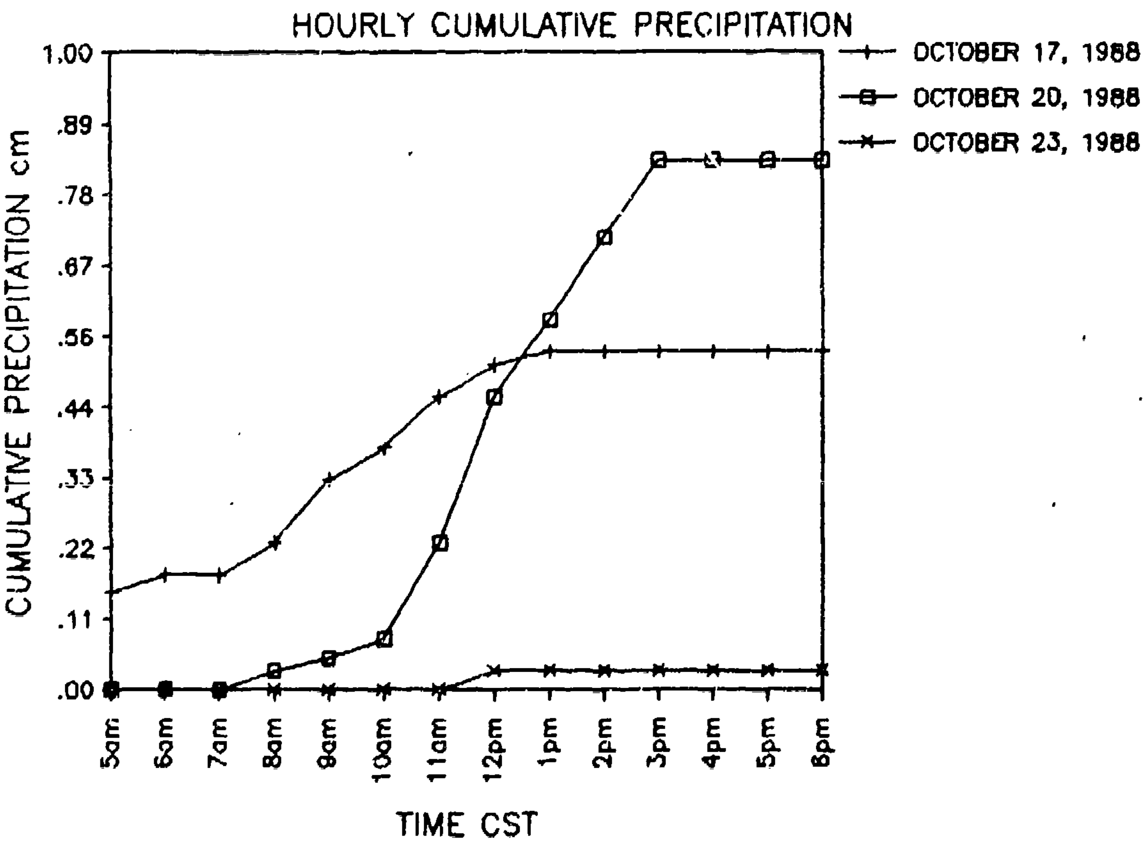


Figure 16. Cumulative Hourly Precipitation for the St.Cloud Weather Station

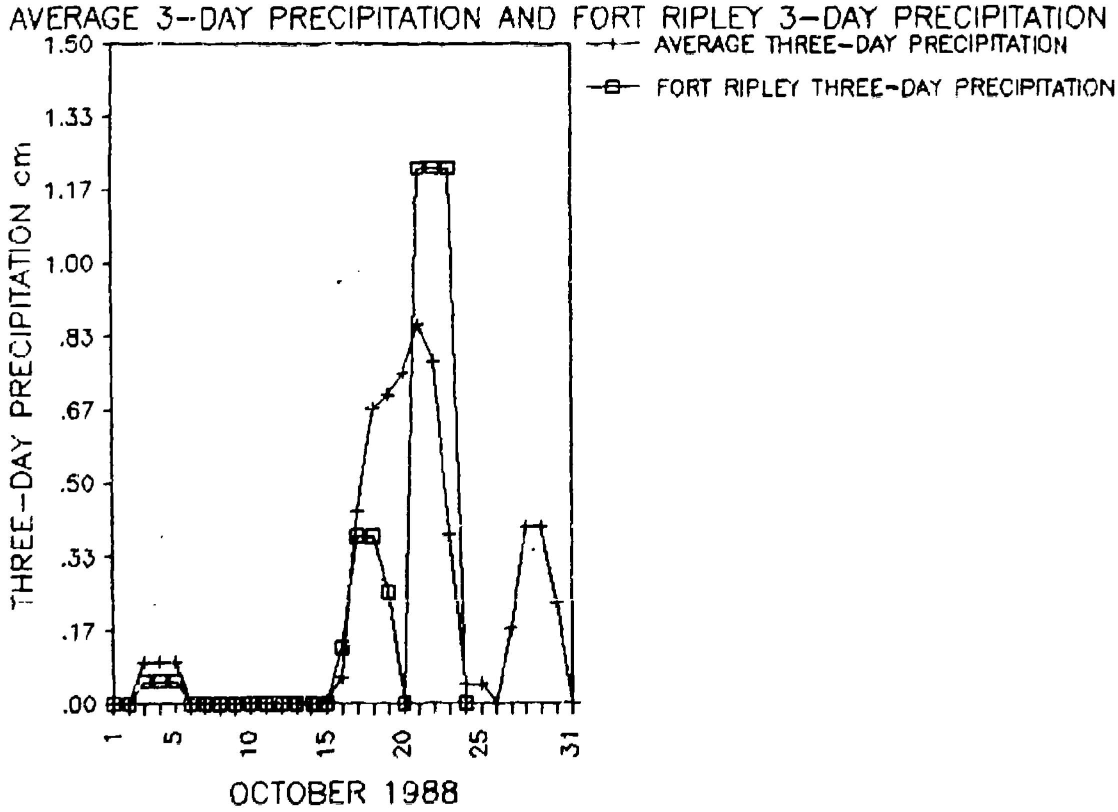


Figure 17. Average Cumulative Three-Day Precipitation for all Weather Stations and for Camp Ripley

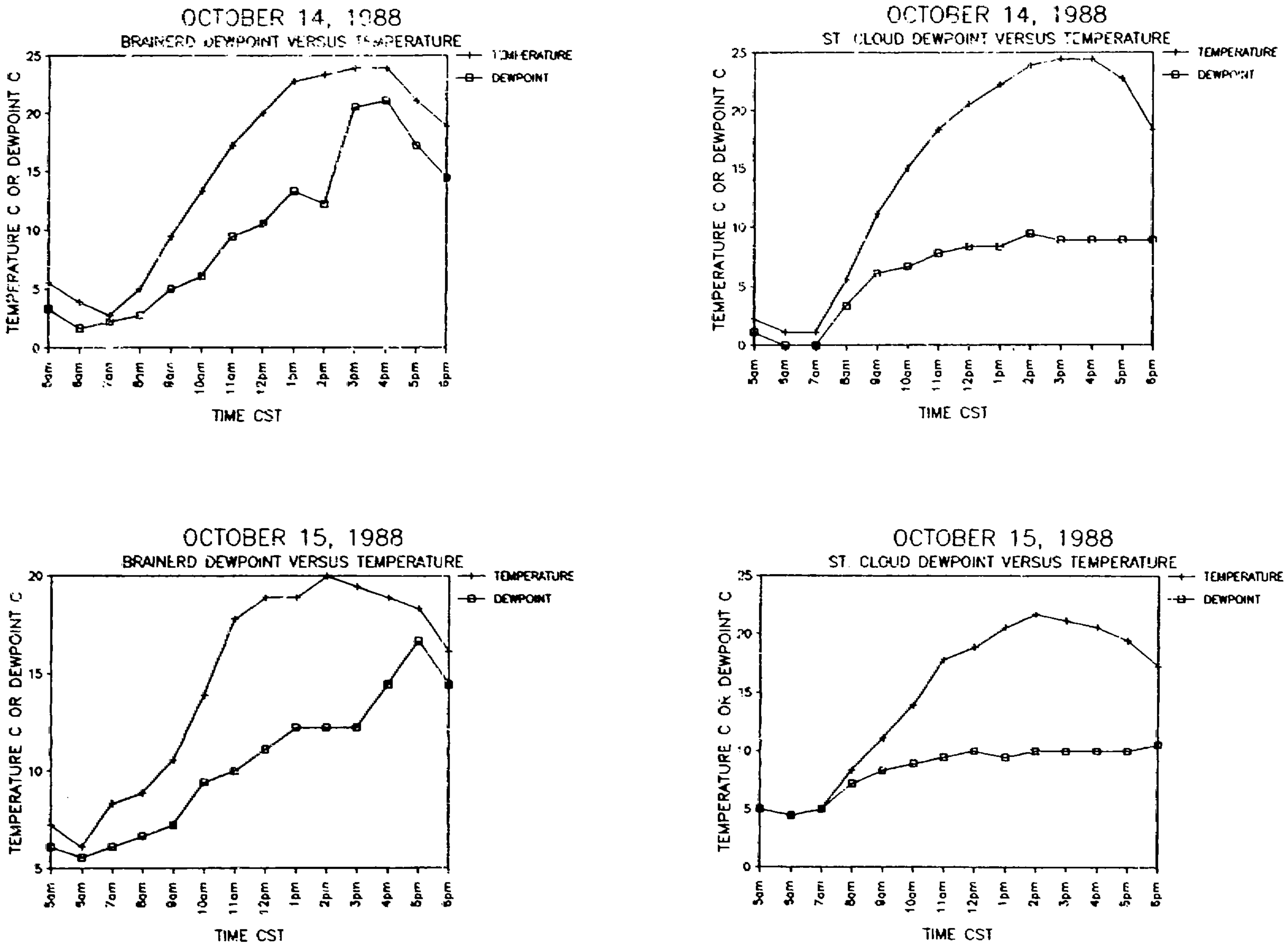


Figure 18. Hourly Dew Points and Temperatures for St. Cloud and Brainerd

90-10253

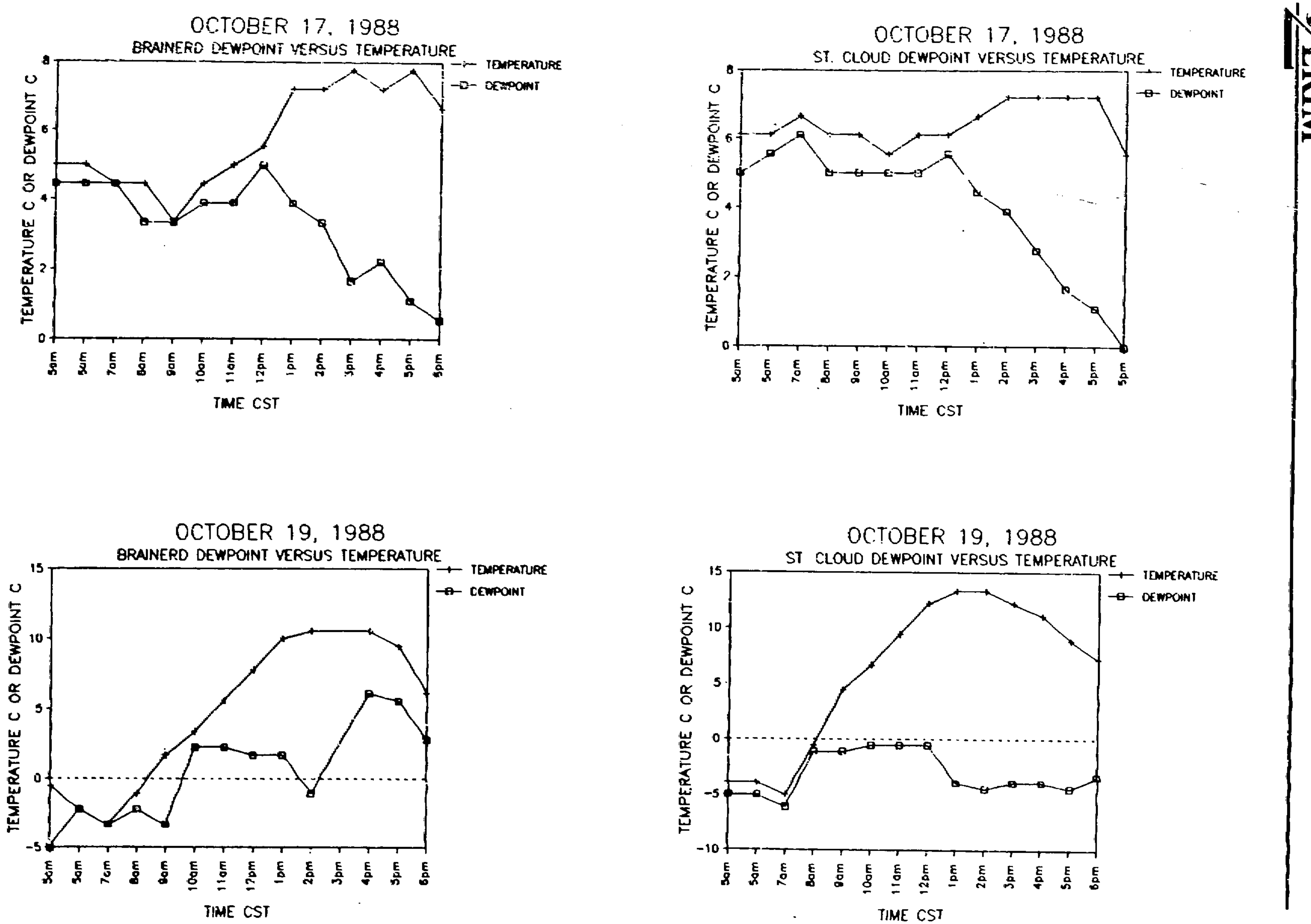


Figure 18 continued. Hourly Dew Points and Temperatures for St. Cloud and Brainerd.

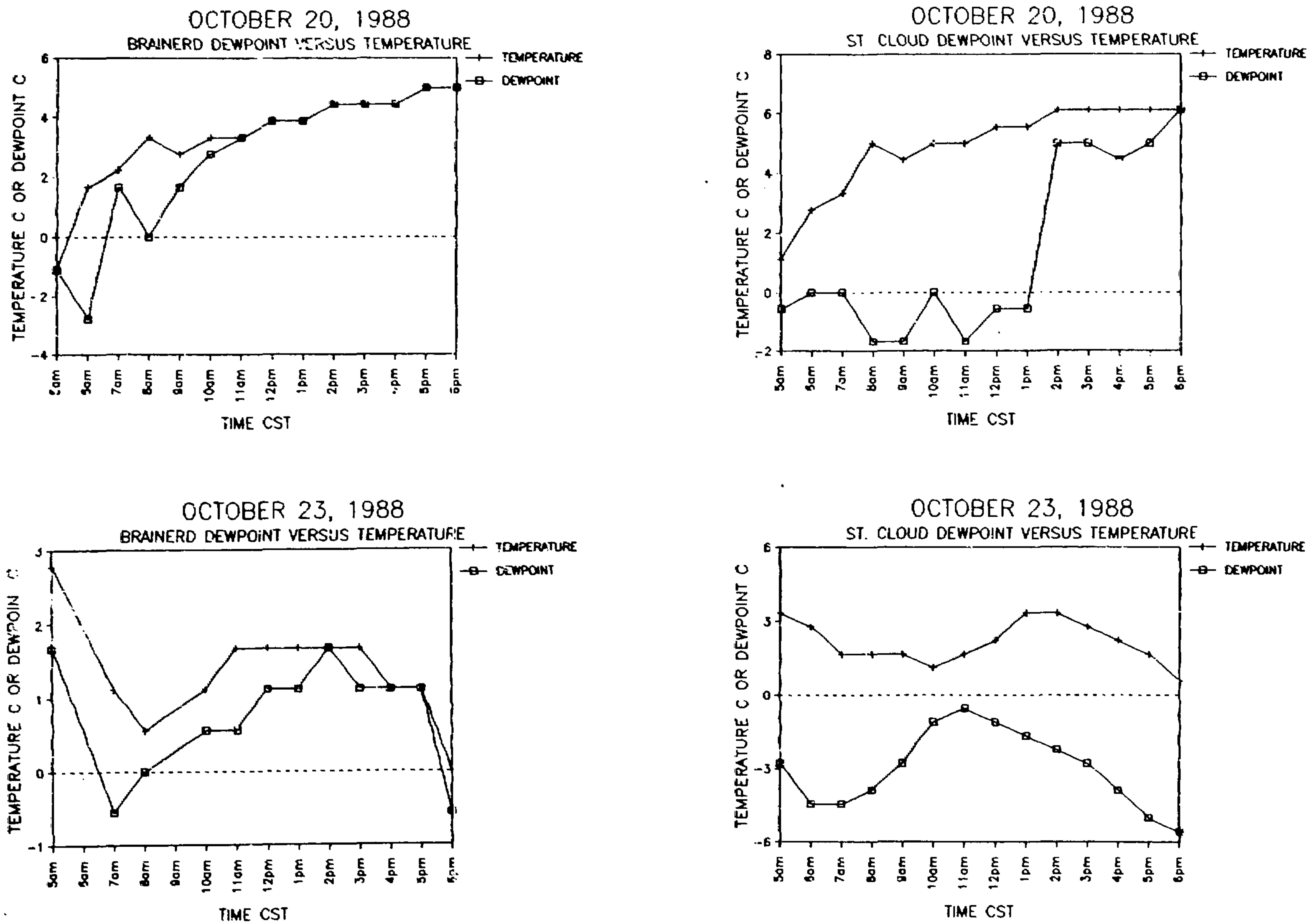


Figure 18 continued. Hourly Dew Points and Temperatures for St. Cloud and Brainerd.

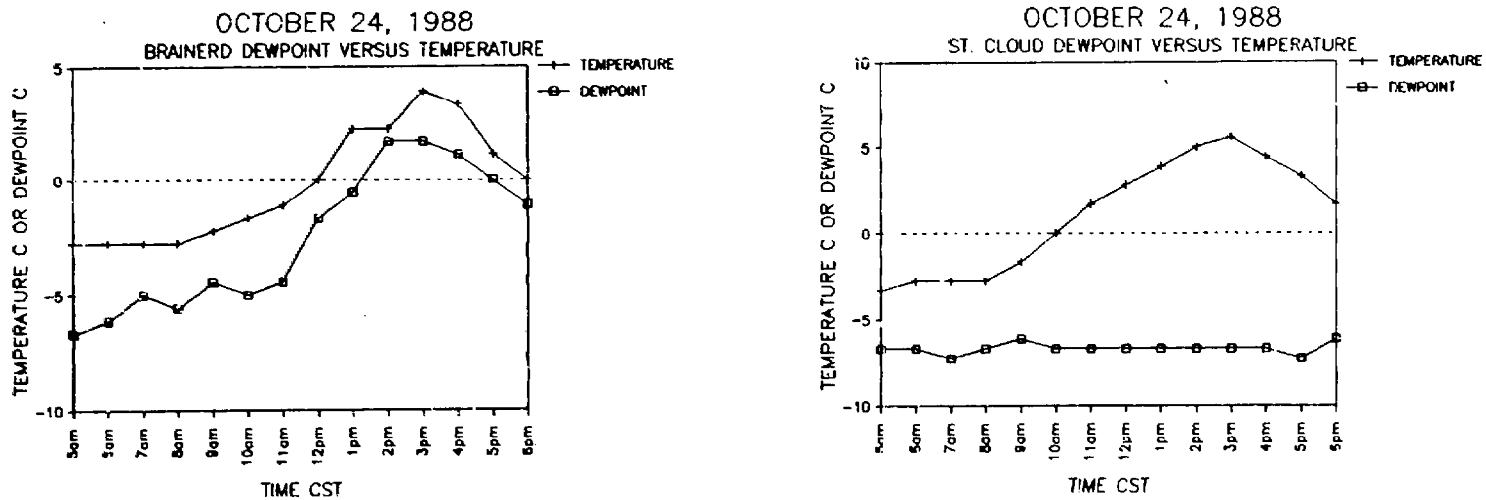


Figure 18 concluded. Hourly Dew Points and Temperatures for St. Cloud and Brainerd.

On 17 October 1988, it was raining in the morning, with the rain stopping in the early afternoon. It was also significantly cooler (-10° C) on this date than during the previous two dates. Thus, during the P-3 SAR flights, the soil/litter moisture was high, and there was surface moisture on the tree surfaces. There was most likely no diurnal variation in the dielectric properties of the tree trunks due to the cloudy conditions.

The 19th of October was a cool, cloudy day. No precipitation occurred during the flight, but the bark of the jack pine was still wet or moist from rain prior to the SAR overflight. No other tree components had any significant residual moisture present on their surfaces. This previous rainfall also resulted in a moist soil/litter layer. Again, due to the cloudy conditions, the diurnal variation in the dielectric properties of the tree components were most likely small.

During the flights of the 20th of October, it was raining heavily, with cool temperatures. Thus, there was some degree of moisture present on all tree surfaces, and the soil/litter layer had a high moisture content as well. Due to the cloudy conditions, the diurnal variation in the dielectric properties of the tree components was most likely small.

The 23rd of October was a cool, cloudy day. However, no frost was present when the stands were checked early in the morning. There had been no significant rainfall during the previous two days, thus the soil/litter layer, although damp, was much dryer than on previous dates. No moisture was present on the surfaces of the constituents of the tree canopies. Due to the cloudy conditions, the diurnal variation in the dielectric properties of the tree components were most likely small.

Finally, on the 24th of October, the conditions were generally cold and cloudy. There was a frost layer present on the trunks and bare branches of the trees, and it is highly likely that the parts of the canopy were frozen because of the low temperatures during the data collection. Due to the cold and cloudy conditions, the diurnal variation in the dielectric properties of the tree components was most likely small.

3.0
STAND GEOMETRY MEASUREMENTS

A variety of tree geometry measurements were made for the FOPEN sites at Camp Ripley. In addition, a literature search was performed to identify a set of allometric equations which describe those tree canopy components which are not easily measured. These measurements and equations are summarized in this section. For convenience, we will first discuss the aspen sites, and then the jack pine stands.

3.1 ASPEN STANDS

In this section, we first present the geometric measurements which were obtained for the aspen stands. Included are biomass measurements made for a sample of the sparse aspen trees. This is followed by a summary of the various allometric equations for tree biomass distribution which were found in the scientific literature.

3.1.1 Geometric Measurements

A survey was performed at each test site in order to characterize the basic canopy geometry. Measurements which were obtained for each site included: (1) tree placement or density; (2) diameter of the tree; (3) height of the tree; and (4) depth of the crown of the tree. The sampling strategy used to obtain these measurements depended on the density of trees within the stand as well as the overall height of the trees.

In measuring the tree canopy, it is critical to adequately sample the geometric properties of the canopy between the radar and the targets being imaged. Ideally, one would measure all the trees within a specified region in front of the target. However, measurement of all trees in this region is rarely practical, except for trees which have low enough stand densities and are short enough so that the heights can

be measured using a rod or staff with height-increment markings (as was the case for the sparse and medium jack pine stands).

The aspen stands had the following characteristics: The sparse aspen had low heights, which made measurement of heights relatively easy, but these sites also had very high tree densities (> 15000 trees per hectare), which made sampling the diameters and spacing of the trees difficult because of both the sheer numbers, as well as the fact that the trees were so close together that movement between trees was difficult. Although the medium aspen stands had a lower tree density which allowed freer movement in and around the trees, the densities were still sufficiently high (3000 to 5000 trees per hectare) to make sampling of individual trees impractical. In addition, the trees in these stands were too tall to be measured using a staff, and had to be measured using an optical ranging device. Finally, the dense aspen stands were of sufficiently low density (1500 trees per hectare) to allow measurement of the spacing and diameter of individual trees, but the height of the trees required the use of an optical ranging device.

The device used to measure tree heights greater than several meters was a Reloscope. This device is accurate to approximately ± 1 m. However, it takes two people a minimum of two minutes to measure the height of a single tree. Thus, because of time constraints, there is a limitation on the number of tree heights that can be measured. Fortunately, for a given tree stand, there is usually a strong linear correlation between tree diameter and tree height. Thus, if a sufficient number of trees are sampled, a linear regression can be established to estimate the tree heights for those trees where only the diameter has been measured. This technique was used for many of the ALP FOPEN test sites.

Based on the above considerations, the following sampling strategies were adopted: For the sparse aspen stands, at each site all trees within two transects parallel to the radar line of site were sampled. The areas of these transects were .6 m wide and 20.4 m long. The location of the centerlines of these transects relative to the FOPEN targets is presented in Figure 19. For all trees within these transects

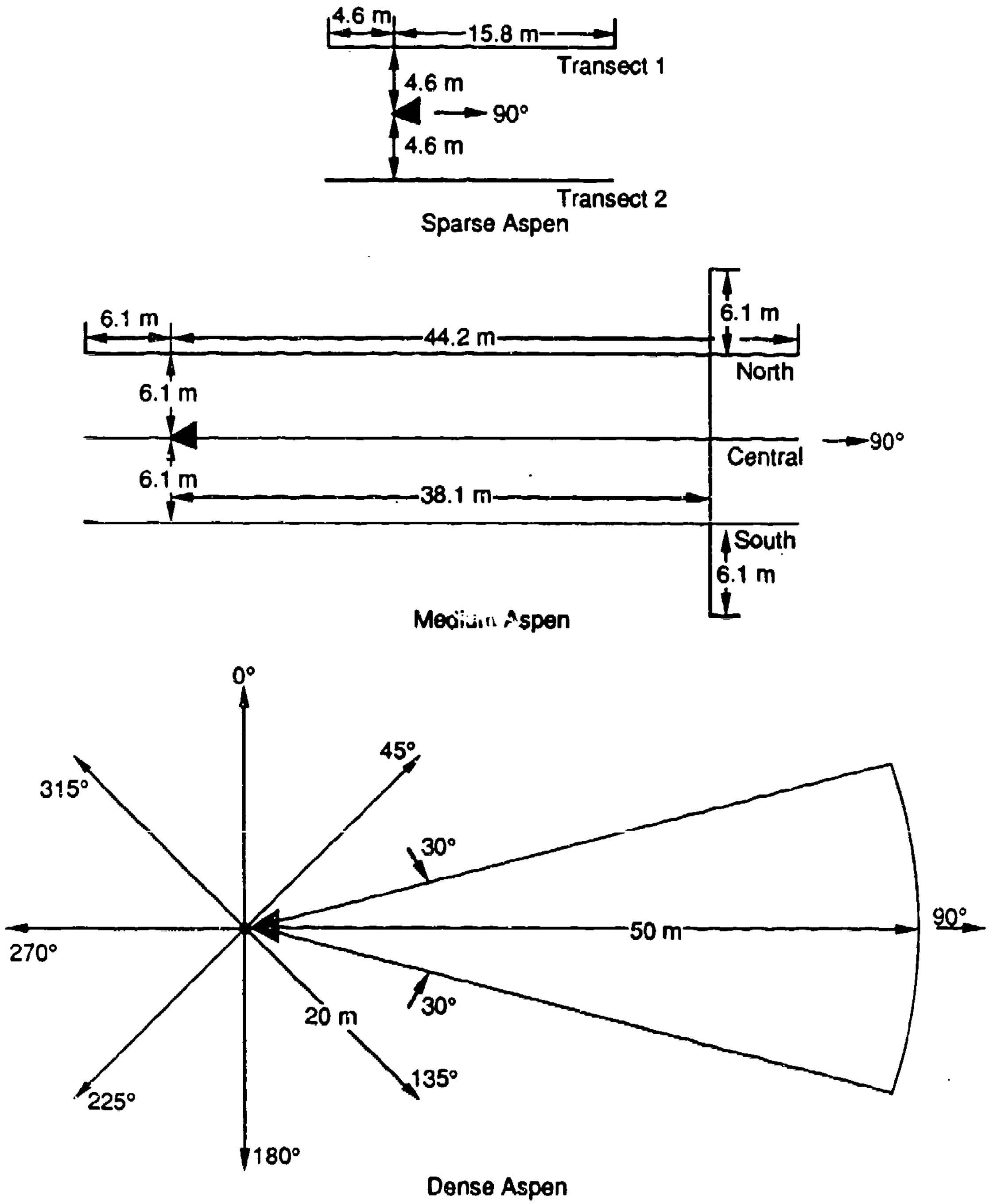


Figure 19. Location of Sampling Areas for the Aspen FOPEN Sites

whose diameter was greater than 1.3 cm, both height and diameter were measured. Heights were measured in feet to the nearest foot, and converted to meters. Diameters were measured at a height of approximately 1 m in centimeters to the nearest 0.1 cm. For those trees whose diameters were less than 1.3 cm, only the number of trees were counted. This latter category was divided into two classes: trees less than 1.2 m tall and trees greater than 1.2 m tall. Very few trees whose diameters were less than 1.3 cm had a height greater than 1.8 m (6 ft). In addition, several trees were harvested in order to measure bole diameter as a function of height, stem numbers, and the relative biomass between branches and boles.

For the medium aspen stand, a transect technique was again used. Four transects were measured for each site (see Figure 19). In this case the width of each transect was 2 m, while the length of the transect was 50.3 m. The diameters of all trees within these transects were measured at a height of 1.5 m above ground to the nearest 0.5 cm. In order to be able to obtain an estimate of the homogeneity of the stand, the transects were divided into seven 6.1 meter segments and one 7.6 m segment. In addition, the distance and direction to and diameter (to the nearest 0.1 cm) of all large trees within 40 m of the target location were noted. A total of 79 trees were measured from the entire stand to determine the relationship between tree diameter and height, while 29 trees were measured to determine the relationship between tree diameter and the height to the lowest living branch (from which canopy depth can be estimated). These heights were measured in yards and converted to meters.

For the dense aspen stands from each reflector, the distance, heading, diameter and species of all trees which fell within a 30° arc with a radius of 40 m were recorded. The diameters were measured to the nearest 0.1 cm. The 30° arc was centered at a heading of 90°. In addition, the diameters and species of all trees within a series of 20 m by 5 m transects were recorded. These transects were spaced every 45°, as illustrated in Figure 19. The starting point of these transects was either at the target site, or 5 m from the target site, in order to

avoid overlap with other transects. To sample the homogeneity of tree spacing, these transects were divided into 5 m increments. Note that for one site (site 5), all trees in a 20 m arc from 105° to 250° were sampled for direction and distance to the target location. Because of length of time required for this sampling method, the above transect technique was implemented. Finally, a total of 70 trees were measured from the entire stand to determine the relationship between tree diameter and height, while 27 trees were measured to determine the relationship between tree diameter and the height to the lowest living branch.

3.1.1.1 Sparse Aspen Stand

Table 5 summarizes the average tree density, diameter and height measurements from the sparse aspen stands. From these data, we can see that the diameters and average heights of the aspen trees were fairly uniform throughout the different stands. However, the density of both the larger trees and smaller trees had significant variation between the different stands.

Figure 20 presents a plot of average tree height for each diameter. These data exhibit a strong linear trend for 1.3 cm $\leq$ diameter $\leq$ 4.2 cm, and a slight decrease for the the diameters greater than 4.2 cm.. This decrease may be an anomaly due to the small sample size for the larger diameter trees. Thus, in determining an equation for height as a function of diameter, these points were excluded. Using the data in Figure 20, the follow equation was derived:

$$\text{Ht (m)} = .86 \text{ dia (cm)} + 1.26 \quad (R = .98) \qquad (1)$$

where Ht is the height of the tree, dia is the diameter of the tree and R is the linear regression coefficient.

Figure 21 presents histograms for the distributions of the heights and diameters for all the sparse aspen sites and predicted versus actual probability density function curves for these histograms. The

TABLE 5

SUMMARY OF SPARSE ASPEN STAND MEASUREMENTS

Site	Trees per hectare > 1.3 cm	Trees per hectare < 1.3 cm	Diameter (cm) Average	Diameter (cm) Std Dev	Height (m) Average	Height (m) Std Dev
1	18072	117671	2.31	.68	3.26	.78
2	15200	127600	2.35	.88	3.44	.90
3	16000	108400	2.51	.90	3.16	.73
4	23600	118800	2.10	.57	3.30	.63
5A	20000	143200	2.40	.87	3.12	.92
5B	17600	114400	2.24	.70	3.07	.76
6	16800	128400	2.49	.83	3.53	.82
Average	18182	122639	2.33	.79	3.27	.81
Standard Dev.	2634	10627				

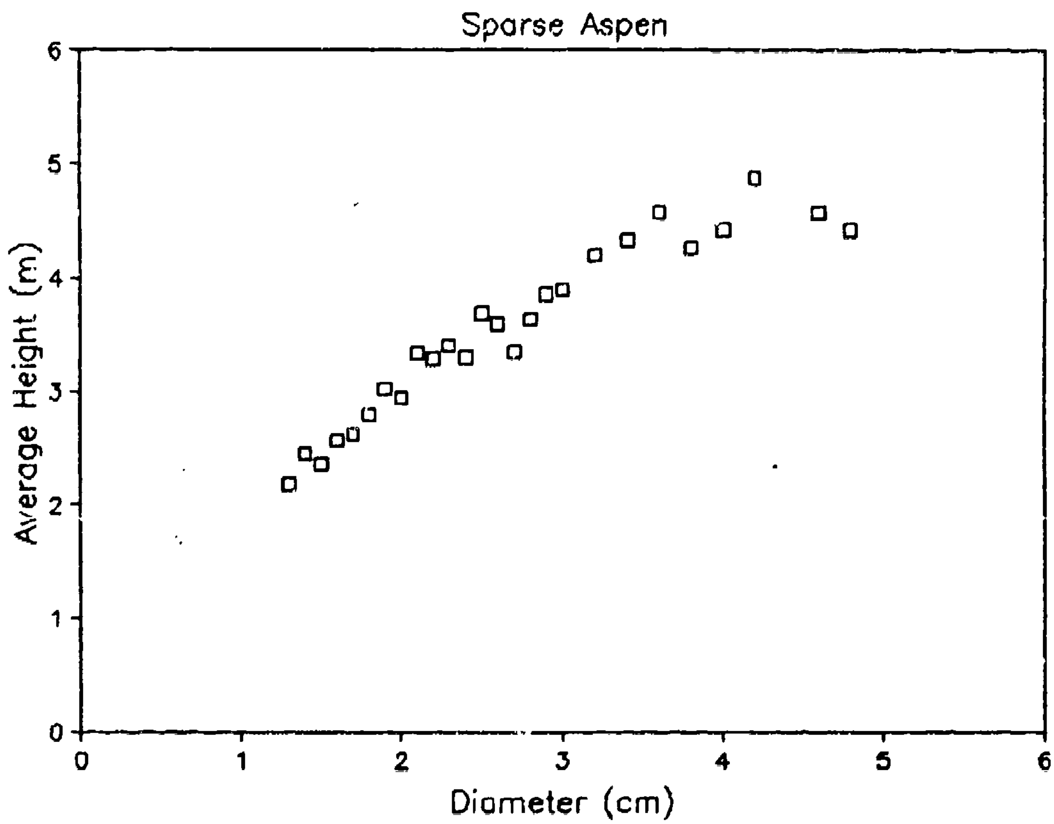


Figure 20. Plot of Average Tree Height as a Function of Tree Diameter for the Sparse Aspen Stand

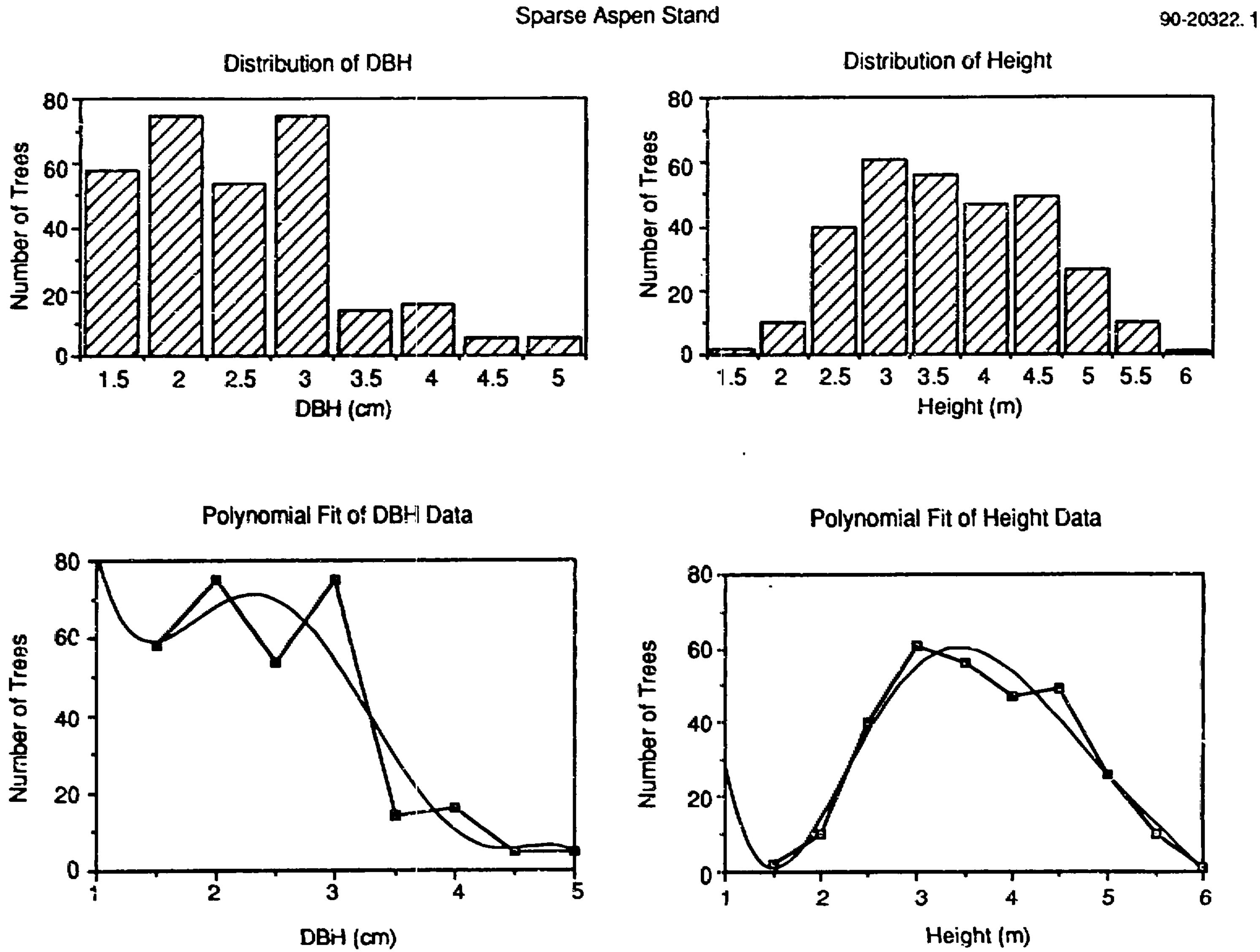


Figure 21. Histogram Plots of Diameters and Heights and PDF Curves for All Sparse Aspen Sites Combined

histograms and PDF curves for the individual sites are presented in Figures 22 through 27. The predicted PDF polynomials were generated using the Apple Computer Cricket Graph software package. The equations for the PDFs are summarized in Table 6.

For four different trees, diameter versus height measurements were obtained in order to determine the overall geometric shape of the tree boles for the aspen saplings found in the sparse aspen stands. A plot of these data are presented in Figure 28. Tree boles typically are not conical, but have a convex, curvilinear taper to them. In Figure 28, we also present the best fit polynomial curves to match the measurements. The equations for these polynomials are as follows:

Tree 1 (2.9 cm diameter)

$$\begin{aligned} dia = {} & 3.896 - .020346*(Ht) + 1.7311*10^{-4}*(Ht^2) \\ & - 8.1561*10^{-7}*(Ht^3) + 1.1288*10^{-9}*(Ht^4) \quad (R = .999) \end{aligned} \tag{2}$$

Trees 2 and 3 (2.3 cm diameter)

$$\begin{aligned} dia = {} & 2.9794 - .0069552*(Ht) + 1.0551*10^{-5}*(Ht^2) \\ & - 5.8049*10^{-8}*(Ht^3) \quad (R = .995) \end{aligned} \tag{3}$$

Tree 4 (1.4 cm diameter)

$$\begin{aligned} dia = {} & 2.2769 - .0099014*(Ht) + 8.7439*10^{-5}*(Ht^2) \\ & -4.5275*10^{-7}*(Ht^3) + 6.5601*10^{-10}*(Ht^4) \quad (R = .996) \end{aligned} \tag{4}$$

Several sets of measurements were obtained to measure the relationship between the aboveground biomass components of the aspen. In one set of measurements, four different trees were harvested, and the branches separated from the boles. These samples were then baked in a drying oven at 105° C for 72 hours and weighed. As illustrated in Figure 29, these measurements exhibit a stong linear correlation between

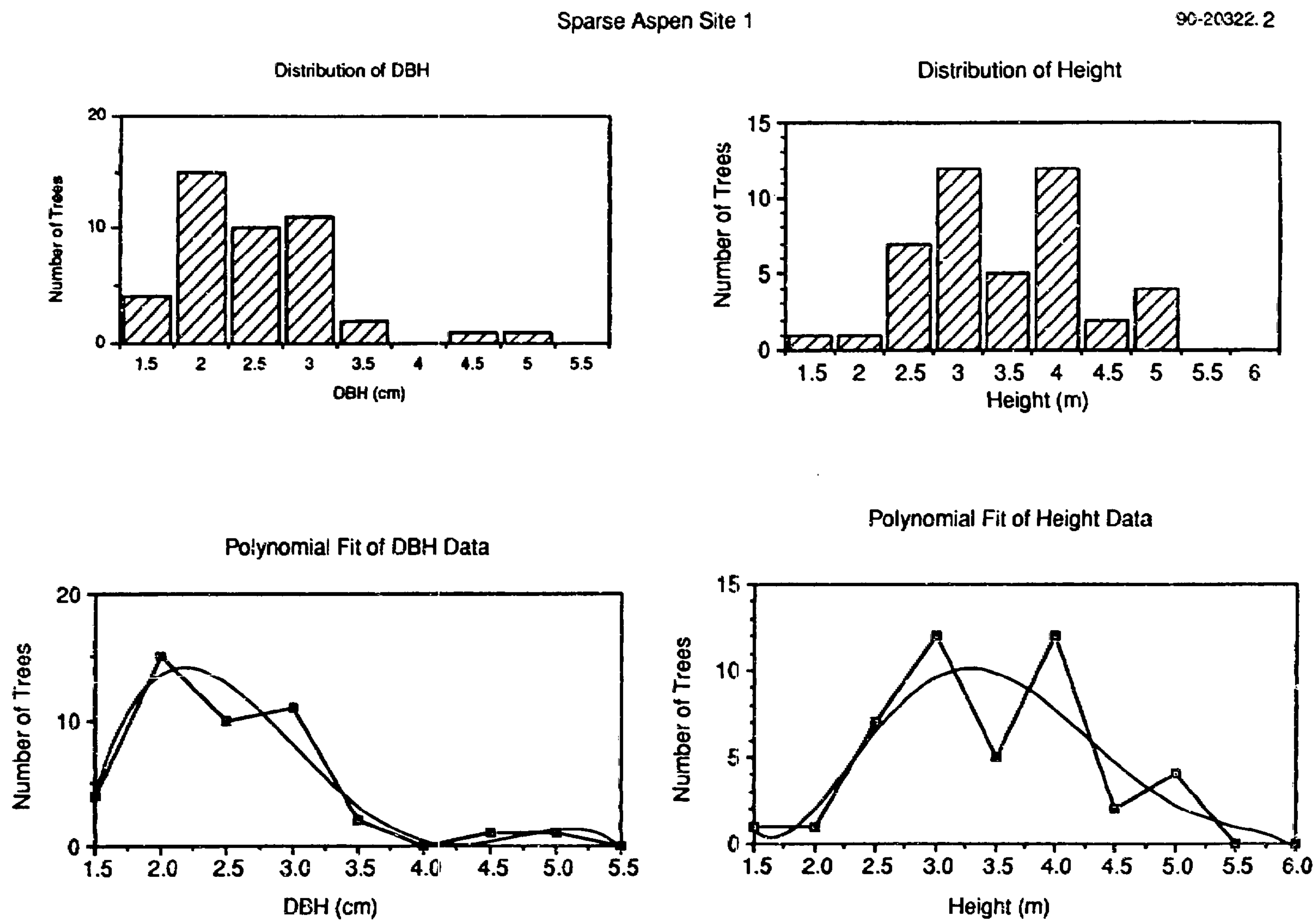


Figure 22. Histogram Plots of Diameters and Heights and PDF Curves for Sparse Aspen Site 1

90-20322.3

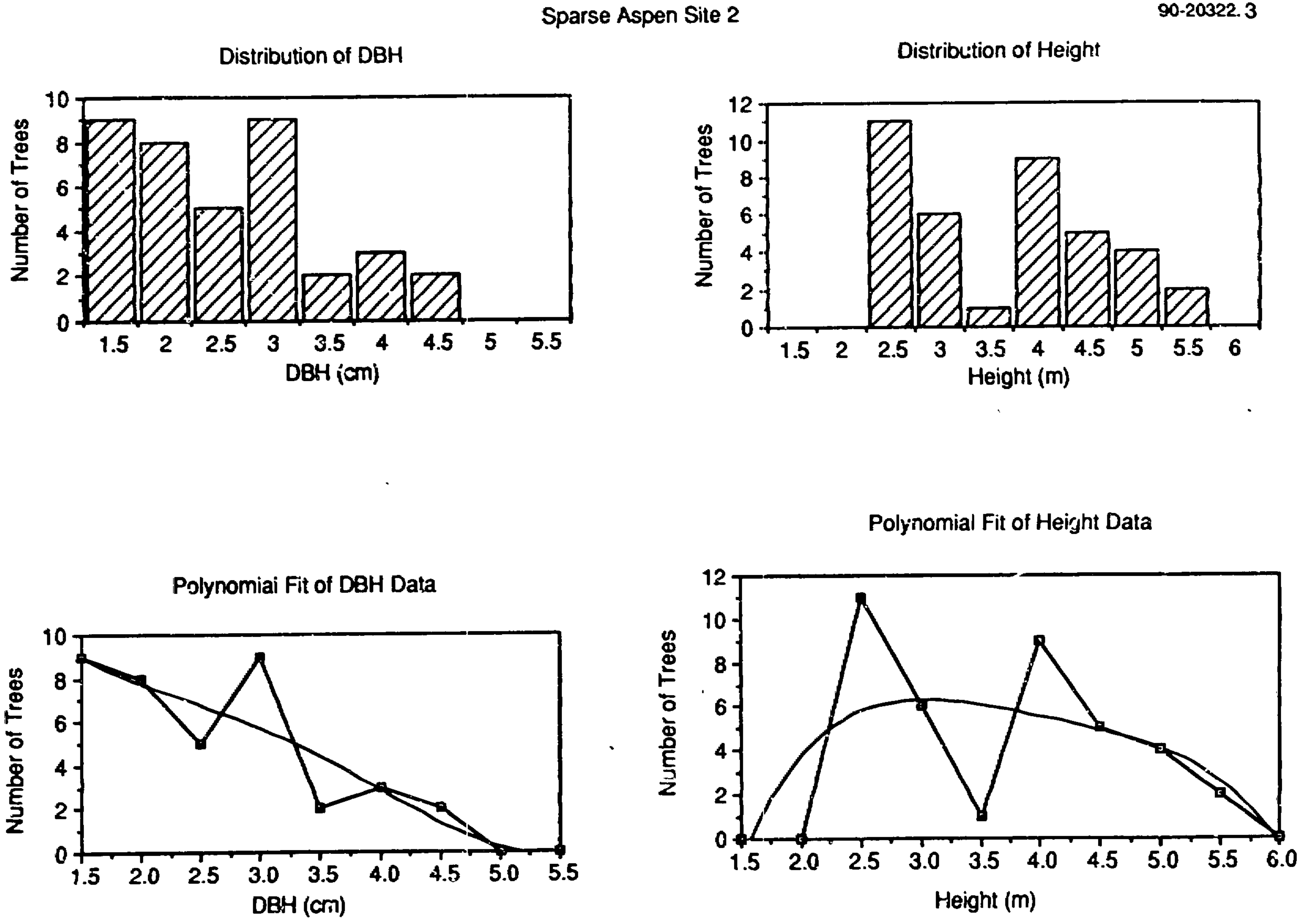


Figure 23. Histogram Plots of Diameters and Heights and PDF Curves for Sparse Aspen Site 2

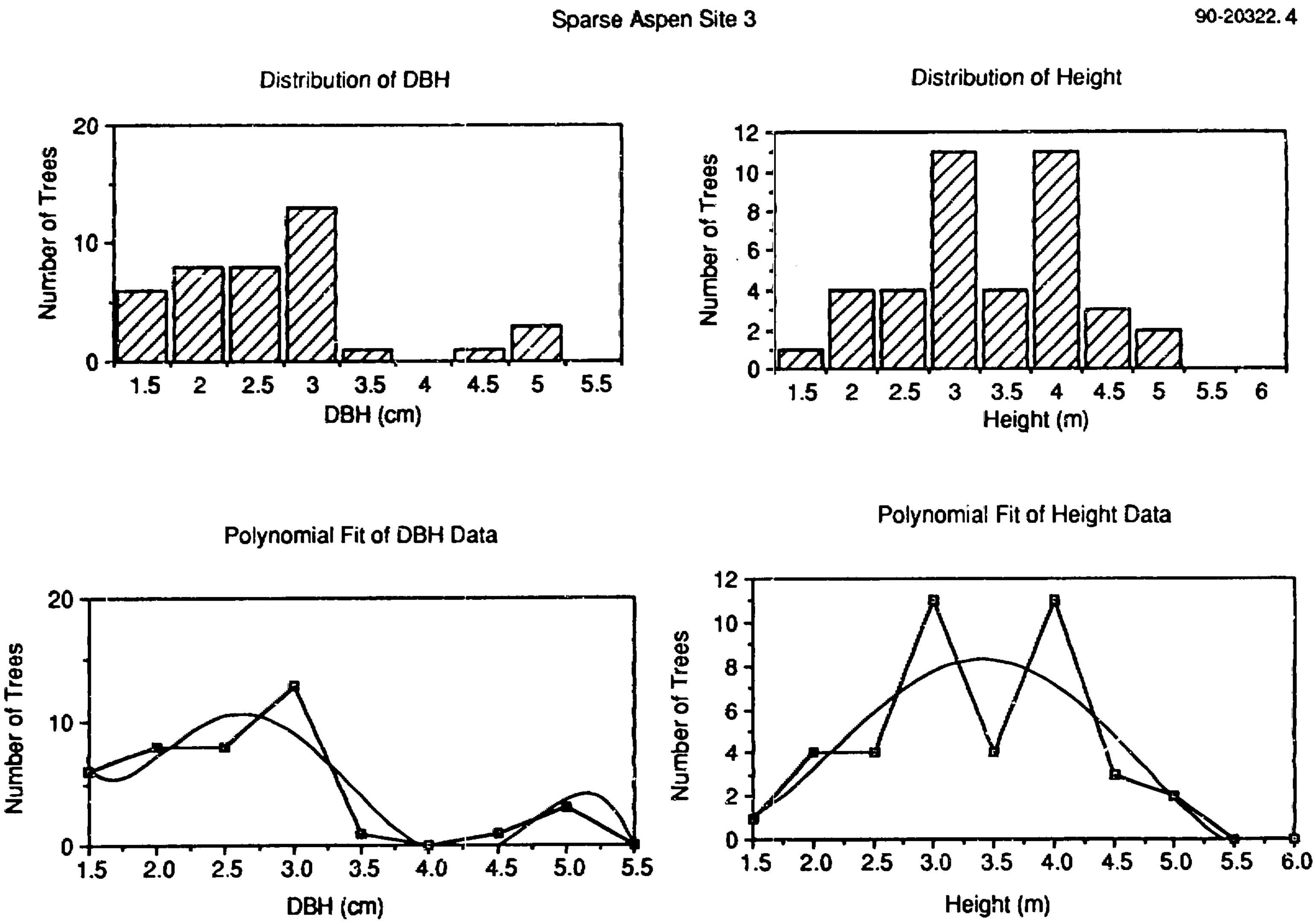


Figure 24. Histogram Plots of Diameters and Heights and PDF Curves for Sparse Aspen Site 3

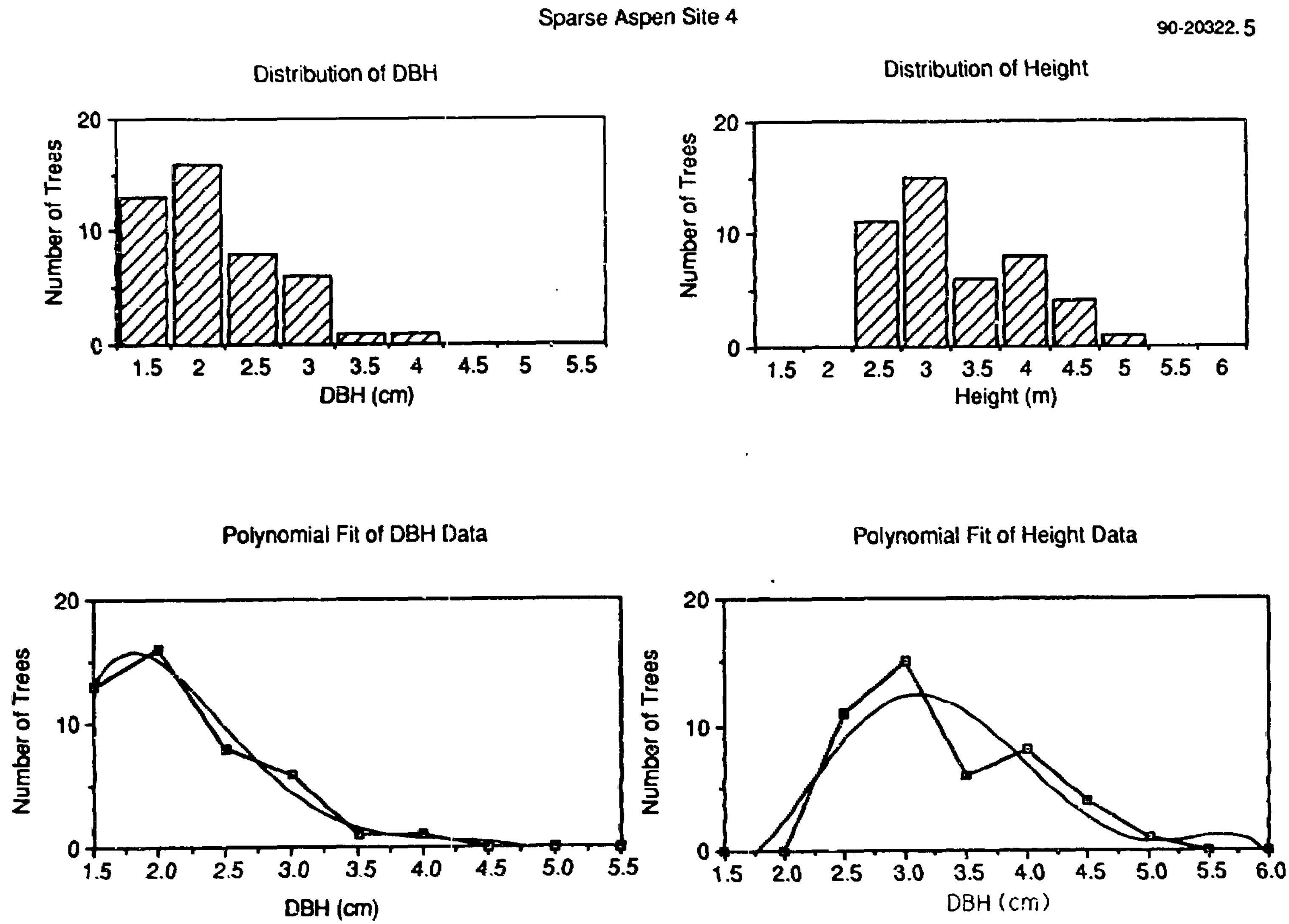
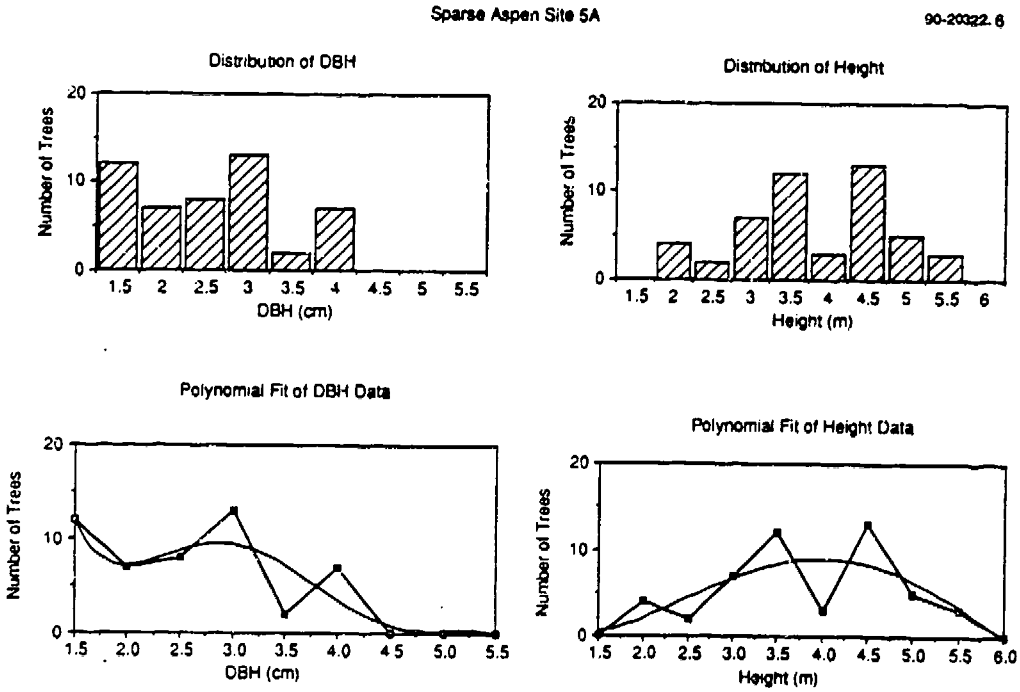


Figure 25. Histogram Plots of Diameters and Heights and PDF Curves for Sparse Aspen Site 4



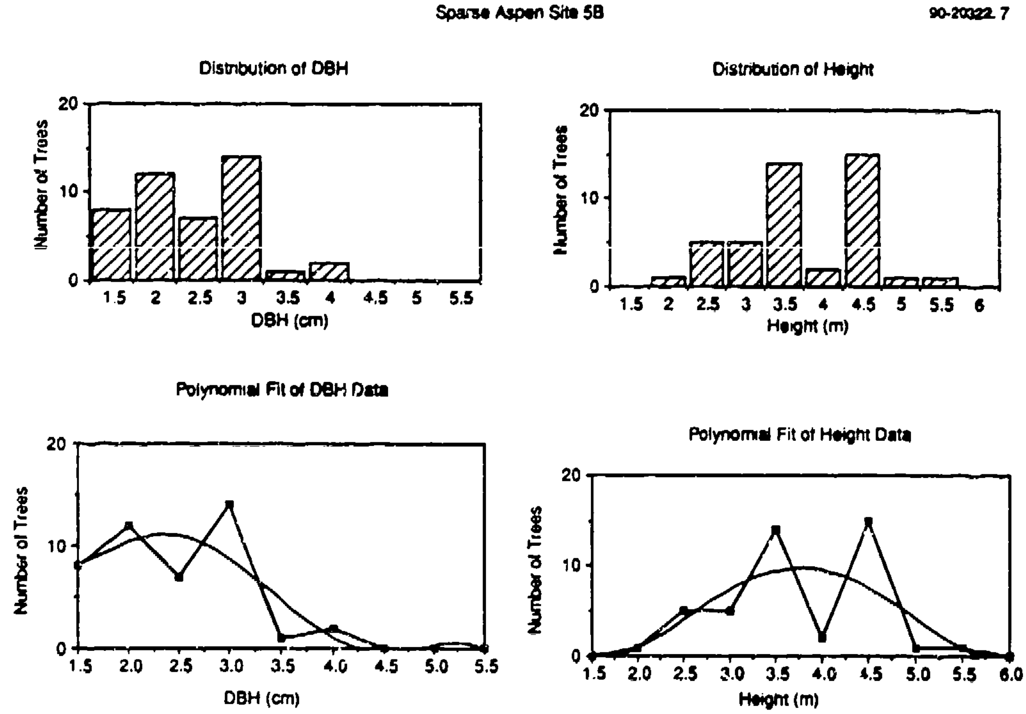


Figure 26. Histogram Plots of Diameters and Heights and PDF Curves for Sparse Aspen Site 5

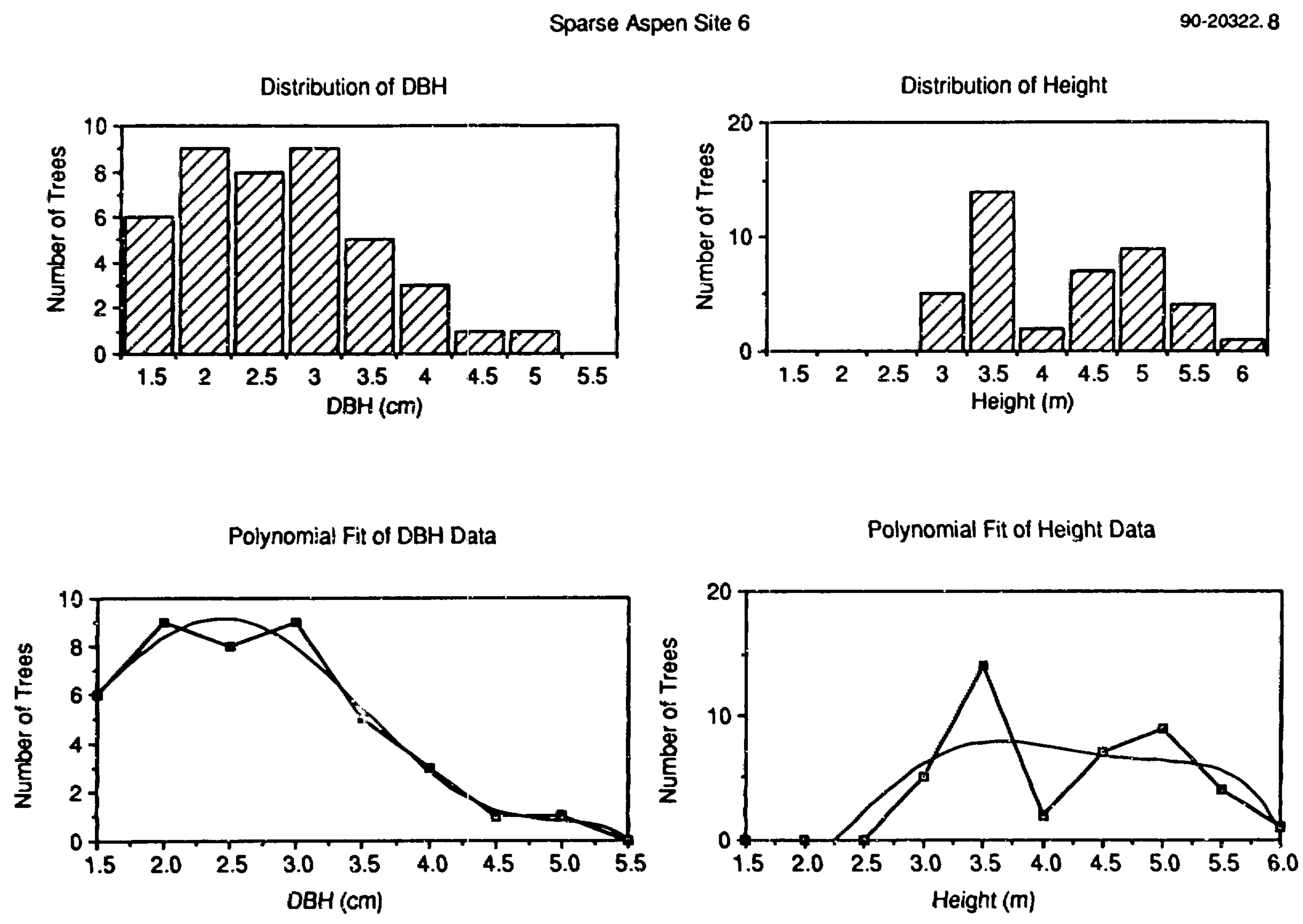


Figure 27. Histogram Plots of Diameters and Heights and PDF Curves for Sparse Aspen Site 6

TABLE 6

SUMMARY OF POLYNOMIAL EQUATIONS FOR DIAMETER AND HEIGHT PDFS FOR THE SPARSE ASPEN SITES

Entire Stand:

Diameter: x = tree diameter in cm

$$y=616.25-1170.2x+911.46x^2-325.54x^3+53.545x^4-3.3026x^5$$
$R^2=0.849$

Height: x = tree height in m

$$y=409.96-744.59x+481.56x^2-135.58x^3+17.422x^4-0.84513x^5$$
$R^2=0.958$

Reflector Site 1:

Diameter: x = tree diameter in cm

$$y=-171.77+235.60x-104.69x^2+19.099x^3-1.2401x^4$$
$R^2=0.916$

Height: x = tree height in m

$$y=126.35-219.98x+139.51x^2-39.696x^3+5.2121x^4-0.25846x^5$$
$R^2=0.683$

Reflector Site 2:

Diameter: x = tree diameter in cm

$$y=19.798-14.045x+6.4961x^2-1.4768x^3+0.11655x^4$$
$R^2=0.811$

Height: x = tree height in m

$$y=-45.758+53.032x-19.817x^2+3.2432x^3-0.20047x^4$$
$R^2=0.426$

Reflector Site 3:

Diameter: x = tree diameter in cm

$$y=298.39-552.37x+390.77x^2-128.91x^3+19.944x^4-1.1692x^5$$
$R^2=0.805$

Height: x = tree height in m

$$y=16.788-31.540x+20.103x^2-4.5097x^3+0.32634x^4$$
$R^2=0.648$

TABLE 6 (concluded)

SUMMARY OF POLYNOMIAL EQUATIONS FOR DIAMETER AND HEIGHT PDFS FOR THE SPARSE ASPEN SITES

Reflector Site 4:

Diameter: x = tree diameter in cm

$$y=-217.37+385.87x-237.16x^2+67.614x^3-9.1865x^4+0.48205x^5$$
$$R^2=0.976$$

Height: x = tree height in m

$$y=186.76-342.63x+227.82x^2-68.136x^3+9.3986x^4-0.48821x^5$$
$$R^2=0.814$$

Reflector Site 5A:

Diameter: x = tree diameter in cm

$$y=263.86-422.67x+264.30x^2-78.073x^3+10.925x^4-0.58462x^5$$
$$R^2=0.748$$

Height: x = tree height in m

$$y=10.924-19.990x+11.772x^2-2.2556x^3+0.13287x^4$$
$$R^2=0.552$$

Reflector Site 5B:

Diameter: x = tree diameter in cm

$$y=69.470-135.54x+108.33x^2-38.592x^3+6.2051x^4-0.36923x^5$$
$$R^2=0.748$$

Height: x = tree height in m

$$y=43.758-68.486x+35.861x^2-7.1033x^3+0.47086x^4$$
$$R^2=0.473$$

Reflector Site 6:

Diameter: x = tree diameter in cm

$$y=27.333-58.058x+51.587x^2-19.117x^3+3.1049x^4-0.18462x^5$$
$$R^2=0.969$$

Height: x = tree height in m

$$y=189.51-314.05x+191.29x^2-54.004x^3+7.2354x^4-0.37333x^5$$
$$R^2=0.548$$

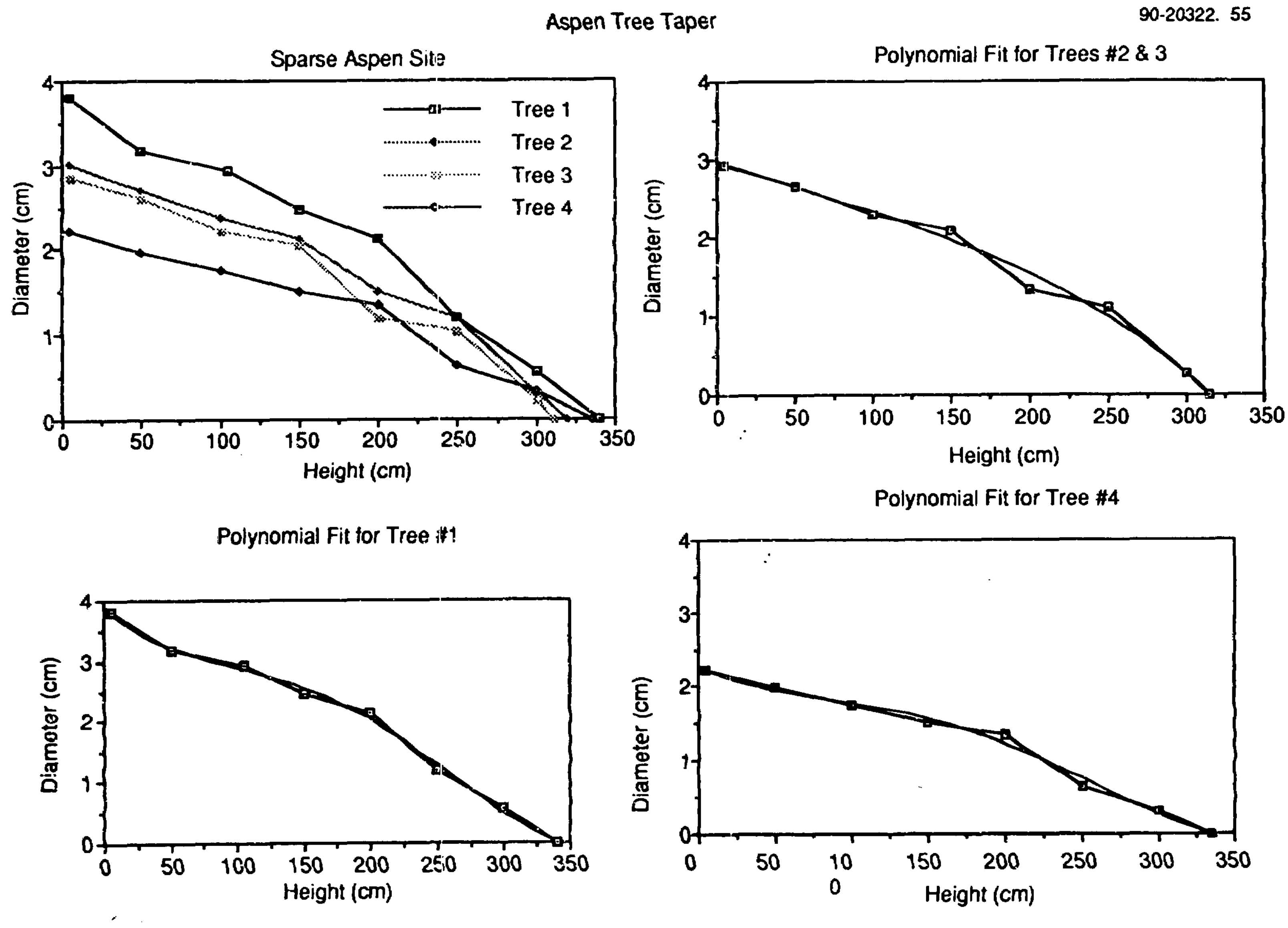


Figure 28. Relationship Between Diameter versus Height for 4 Aspen Saplings

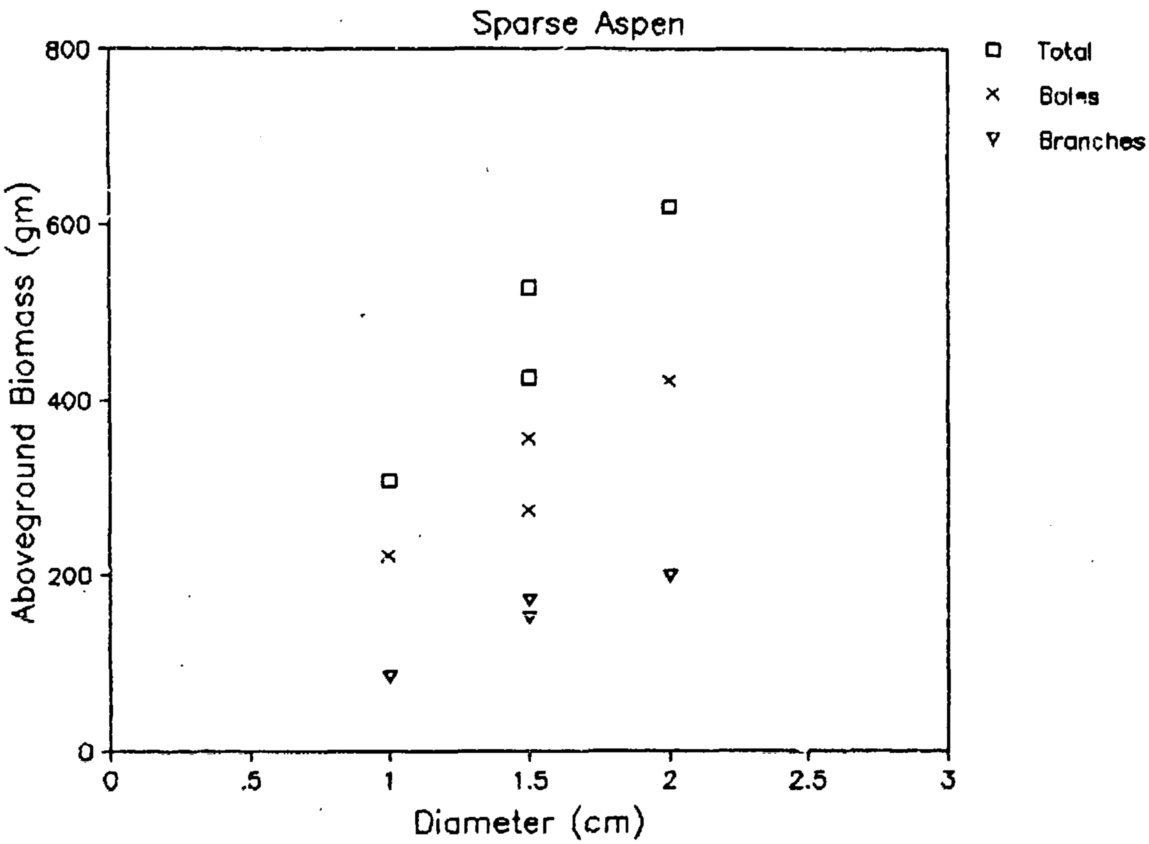


Figure 29. Relationship Between Diameter and Aboveground Biomass for Sparse Aspen Stand Trees

diameter and biomass. These relationships are expressed in the following equations:

$$B_{tr}\ (gm) = 199.2\ dia\ (cm) + 19.0\ (R = .92) \qquad (5)$$

$$B_b\ (gm) = 113.0\ dia\ (cm) - 17.6\ (R = .96) \qquad (6)$$

$$B_{to}\ (gm) = 312.2\ dia\ (cm) + 1.4\ (R = .95) \qquad (7)$$

where B_{tr} is the trunk biomass, B_b is the branch biomass and B_{to} is the total biomass.

A second set of aspen saplings were harvested to determine: (1) the density of poplar wood; (2) the total number of first and second order branches per tree; and (3) the individual weights of these branches. These data are summarized in Table 7. Note from Table 7, that the average height and diameters of these trees were somewhat larger than those present at the time of the SAR data collection (see Table 5). However, if we compare the total estimated average stem weight in Table 6 with the weight estimated from Eq. (6) using the average diameter, fairly good agreement is achieved (402 versus 427 gm).

Finally, a subset of the secondary branches from the sparse aspen stands was measured for diameter and length. These data are summarized in Table 8. Figure 30 presents the histogram plots and PDF curves for these data.

Figure 31 presents a plot of stem length versus diameter for the secondary branches of the aspen branches. From these data, the following relationship

$$L\ (cm) = 86.69\ dia - 8.08\ \ (R = .77) \qquad (8)$$

where L is the stem length.

From Table 7 it can be seen that the overall density of the wood is somewhat proportional to the position in the tree. Because no weights were collected in the field, it was not possible to determine the percent weight of moisture in the tree components. For these

TABLE 7

MISCELLANEOUS MEASUREMENTS FROM THREE TREES IN THE SPARSE ASPEN STAND

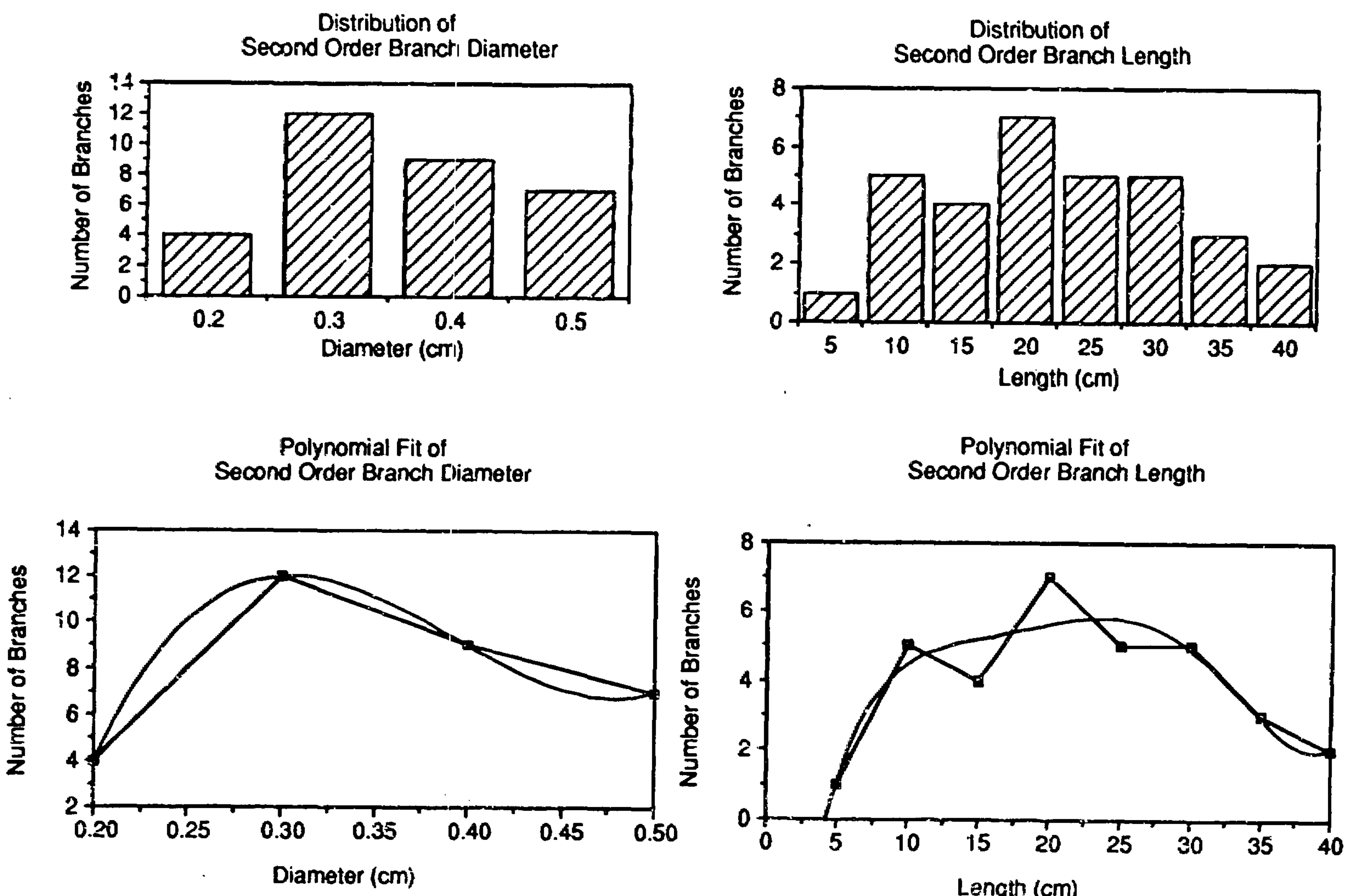
	Tree 1	2	3	Avg	St Dev
Wood Density (gm/m^3)					
Top	.604	.765	.595	.654	.078
Middle	.405	.541	.410	.452	.063
Bottom	.422	.607	.436	.488	.084
Tree Diameter (cm)	4.0	4.2	3.6		
Tree Height (m)	5.6	4.8	5.0		
Branch Statistics					
No.of 1st Order Branches	22	25	27	24.7	2.1
No. of 2nd order branches per first order branch	8.8	13.6	11	11.1	2.0
Wt per 1st order branch (gm)	10.2	14.7	15.1	13.4	2.2
Wt per 2nd order branch (gm)	.3	.2	.2	.3	.045
Total Estimated Weights (gm)					
1st order	224.7	368.7	408.3	333.9	78.9
2nd order	60.4	68.6	74.1	67.7	5.6
Total	285.0	437.3	482.4	401.6	84.4

TABLE 8

SUMMARY OF SECONDARY BRANCH DIAMETER AND LENGTH MEASUREMENTS FROM SPARSE ASPEN STAND SAMPLES

Tree	Diameter (cm)	Length (cm)
1	.38	35.5
	.22	10.5
	.32	20.1
	.21	9.8
	.33	15.5
	.20	4.7
	.25	10.2
	.30	16.0
	.29	15.4
	.40	35.4
2	.32	29.8
	.45	34.5
	.30	18.5
	.21	14.4
	.20	17.1
	.29	16.5
	.25	26.2
	.33	15.5
	.40	31.5
	.30	21.9
	.20	8.7
	.20	6.1
3	.38	19.1
	.40	21.5
	.28	8.9
	.42	30.6
	.30	7.8
	.31	12.0
	.48	26.1
	.35	22.1
	.40	29.1
	.38	21.5

Sparse Aspen



$y=-93.000+875.00x-2350.0x^2+2000.0x^3 \quad R^2=1.000$

$y=-11.250+4.0381x-0.40156x^2+.019741x^3-4.6457*10^{-4}x^4+4.1026*10^{-6}x^5 \quad R^2=0.837$

Figure 30. Histogram Plots of Stem Diameter and Lengths and PDF Curves for Secondary Branches of Aspen Saplings

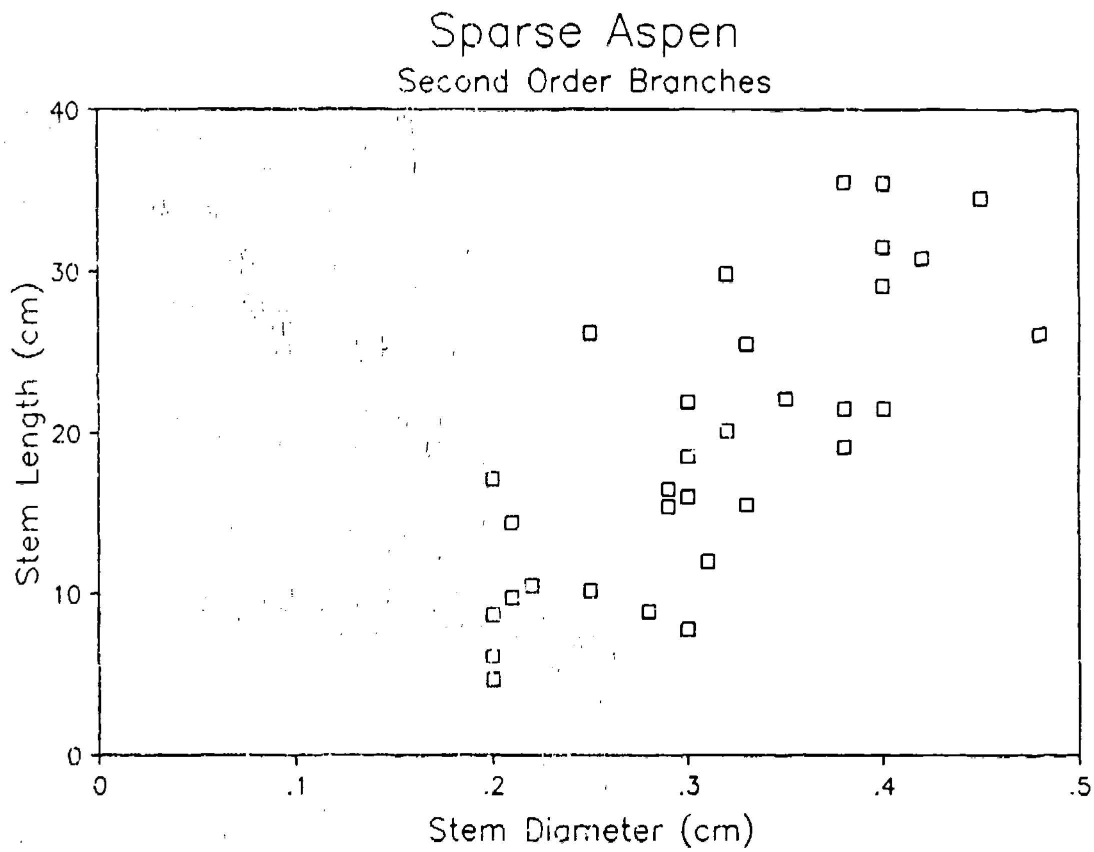


Figure 31. Relationship Between Diameter and Length for Secondary Branches of Aspen Saplings

relationships, we will have to depend on data available from the literature. McLean and Wein (1976) found for 8 year old aspens, the stems and boles had a moisture content of 54% by weight, 20 year old aspens 36%, and 29 year old aspens 35%. Bray and Dudkiewicz (1963) found the following relationships for tree moisture:

<u>41 year old aspen</u>

branches:	41% moisture by weight
boles:	44% moisture by weight

<u>38 year old aspen</u>

branches:	40% moisture by weight
boles:	50% moisture by weight

3.1.1.2 Medium Aspen Stand

Table 9 presents a summary of the average tree parameters derived from the transect measurements for the medium aspen stand, where the tree heights were determined by an allometric equation developed from the tree stand measurements, as discussed below. As with the sparse aspen sites, there is considerable variability in the variation in stand density from site to site. There is more site-to-site variability in the diameter and heights of the trees as well. In comparing the sparse and medium aspen sites, we note the following:

1. The average stand density for aspen trees dropped by over a factor of 4 from 18000 to 4000 stems per hectare;

2. The average tree diameter increased by almost a factor of three from 2.3 to 6.5 cm;

3. The average tree height increased by a factor of three from 3.3 m to 9.7 m; and

4. While smaller trees constituted a major portion of the biomass in the sparse aspen sites, in

TABLE 9

SUMMARY OF MEDIUM ASPEN STAND MEASUREMENTS

SITE	Trees/ Hectare	Diameter (cm) Average	Diameter (cm) Std	Height (m) Average	Height (m) Std
1	5085	5.98	3.30	9.35	3.08
2	3239	5.96	2.89	9.12	2.83
3	4659	7.32	2.86	10.45	2.79
4	3608	5.89	3.38	9.06	3.30
5	3409	6.87	3.76	10.05	3.67
TOTAL	4000	6.49	3.25	9.65	3.18

the medium aspen sites, very few small trees were present in the understory.

Figure 32 presents a plot of tree diameter versus total height and height to the lowest living branch for the medium aspen stand. While a clear linear relationship exists between diameter and total height, the relationship between diameter and height to the lowest living branch is less clear. The regression equations for these relationships are as follows:

Total Tree

$$Ht\ (m) = .98\ dia\ (cm) + 3.3\ (R = .84) \tag{9}$$

Lowest Living Branch

$$Ht\ (m) = .22\ dia\ (cm) + 4.5\ (R = .24) \tag{10}$$

For Eq. (12), the regression and correlation coefficients are so low that this relationship is not very useful in developing the canopy depths for the medium aspen stand. In Figure 33, the relationship between diameter and canopy depth is presented (where canopy depth = [total height] - [height to lowest living branch]). If the two outlying points on this plot are eliminated (i.e., where diameter > 12 cm and depth < 6 m), then the following regression relationship exists

$$C_d\ (m) = .78\ dia\ (cm) - .9\ (R = .70) \tag{11}$$

where C_d is canopy depth.

Figures 34 to 39 present the set of histograms and PDF curves for the medium aspen diameters and heights. The polynomial equations for the PDFs for this stand are summarized in Table 10.

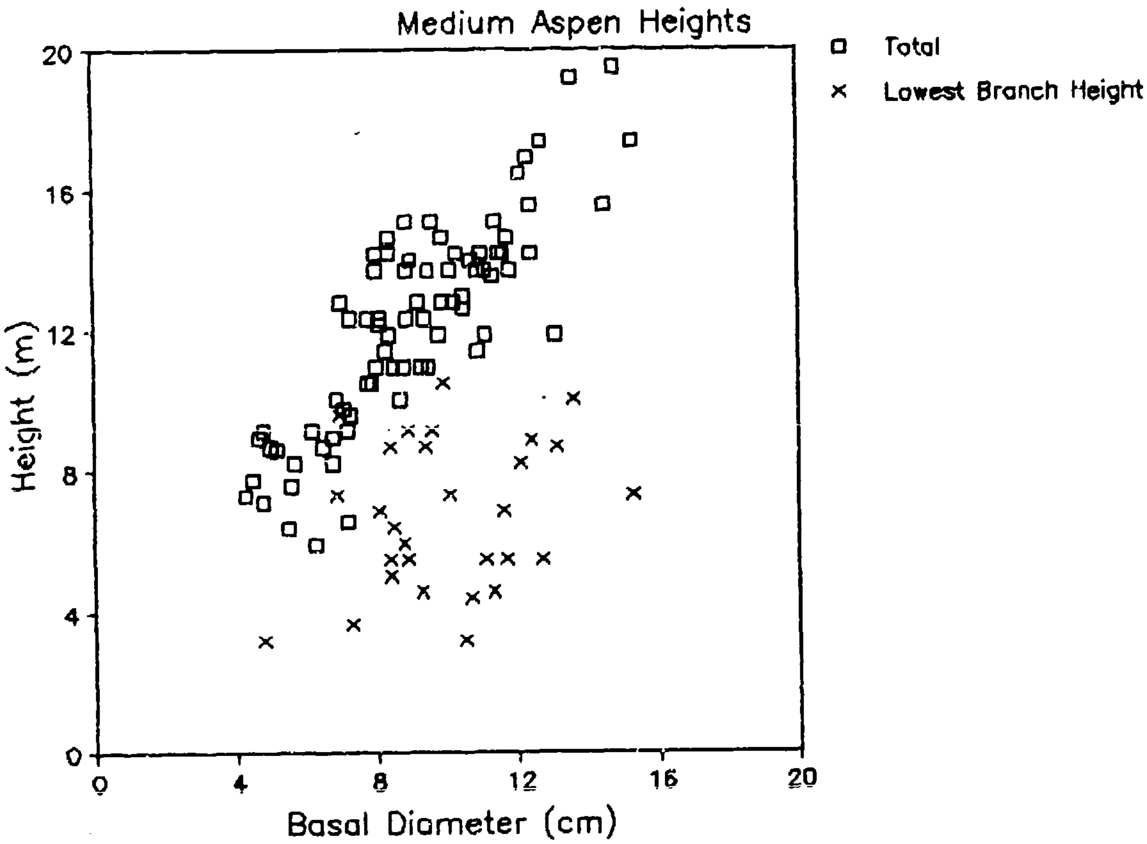


Figure 32. Relationship Between Diameter and Total Height and Height to the Lowest Living Branch for the Medium Aspen Stand

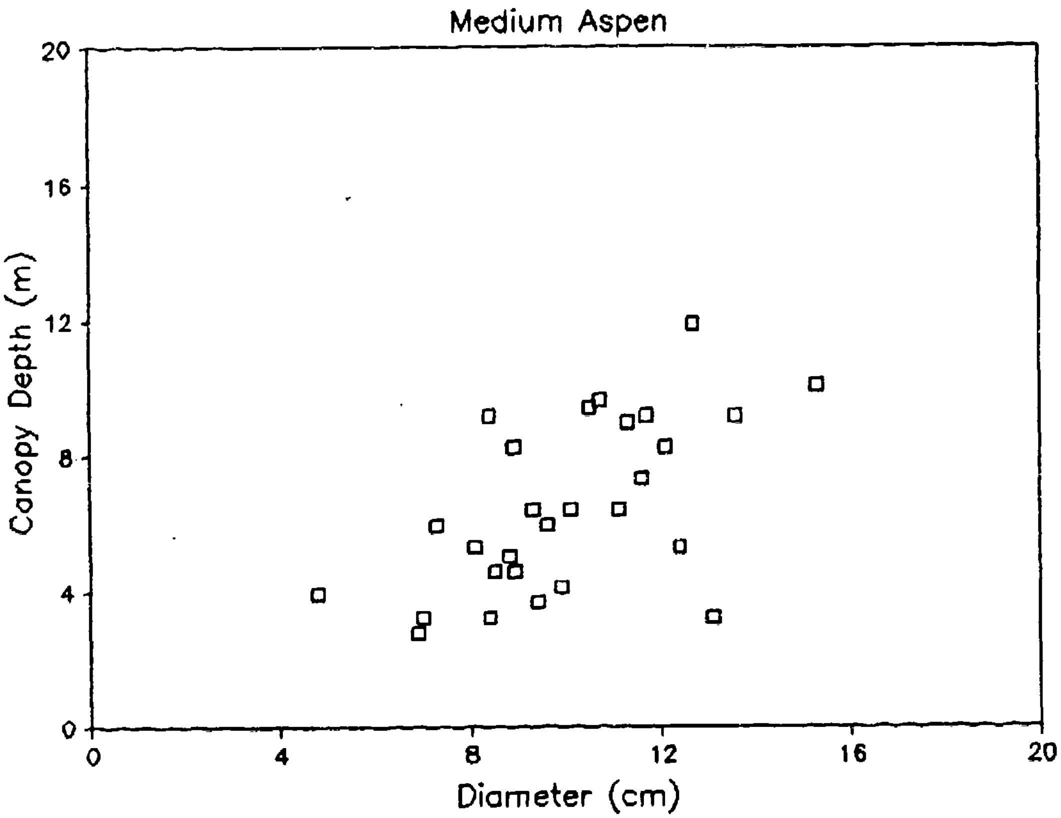


Figure 33. Relationship Between Diameter and Canopy Depth for the Medium Aspen Stand

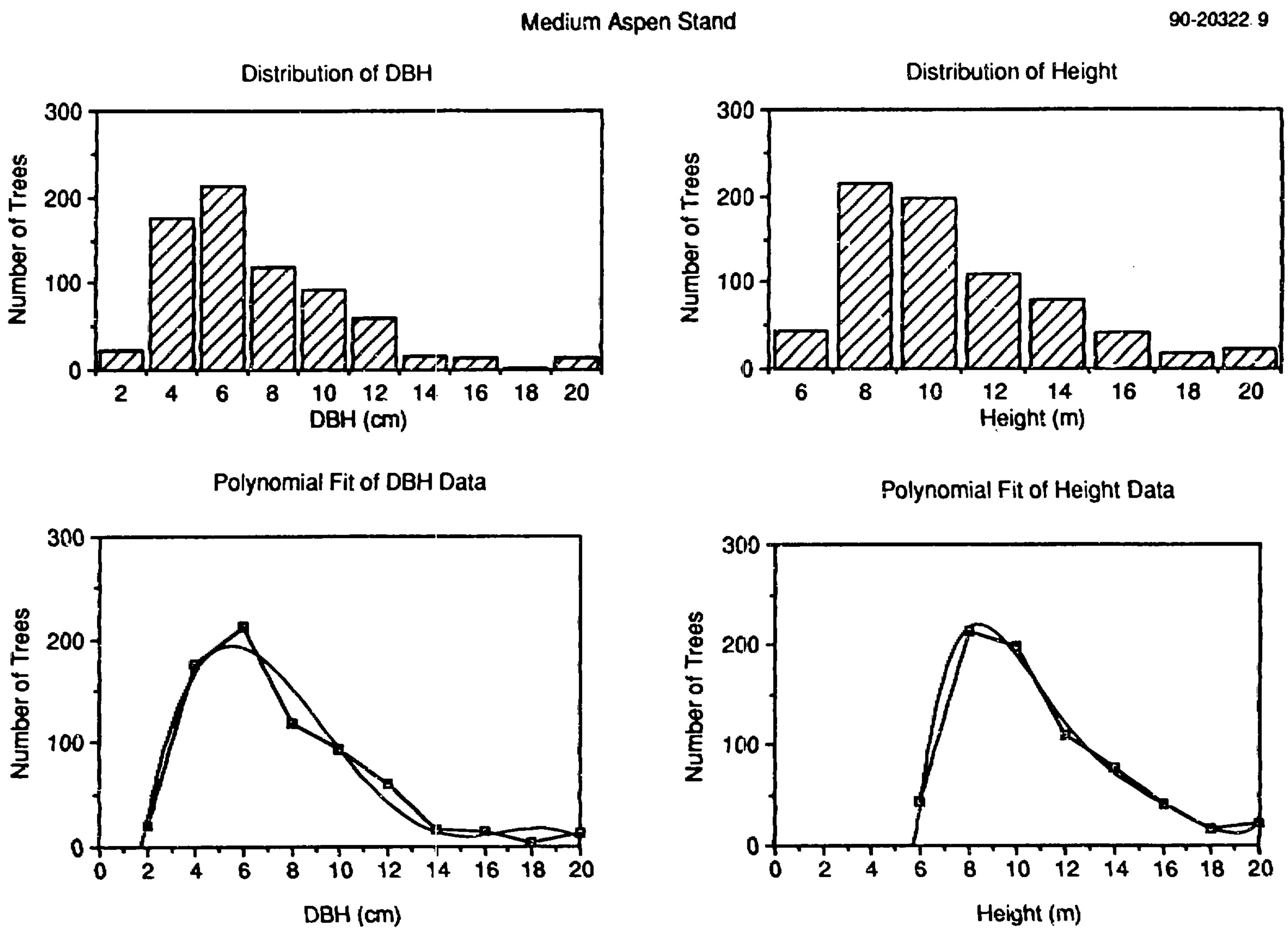


Figure 34. Histogram Plots of Diameters and Heights and PDF Curves for All Medium Aspen Sites Combined

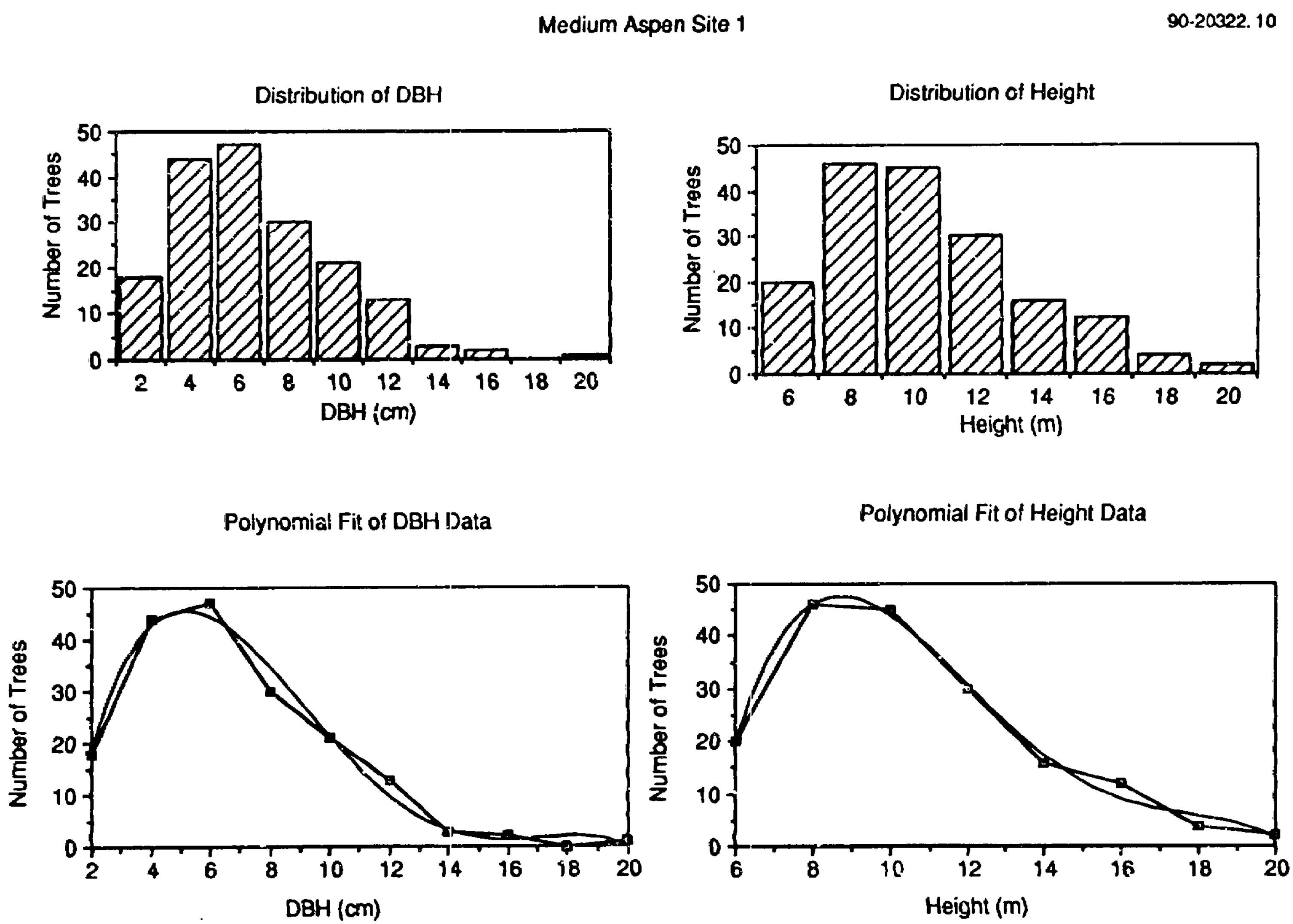


Figure 35. Histogram Plots of Diameters and Heights and PDF Curves for Medium Aspen Site 1

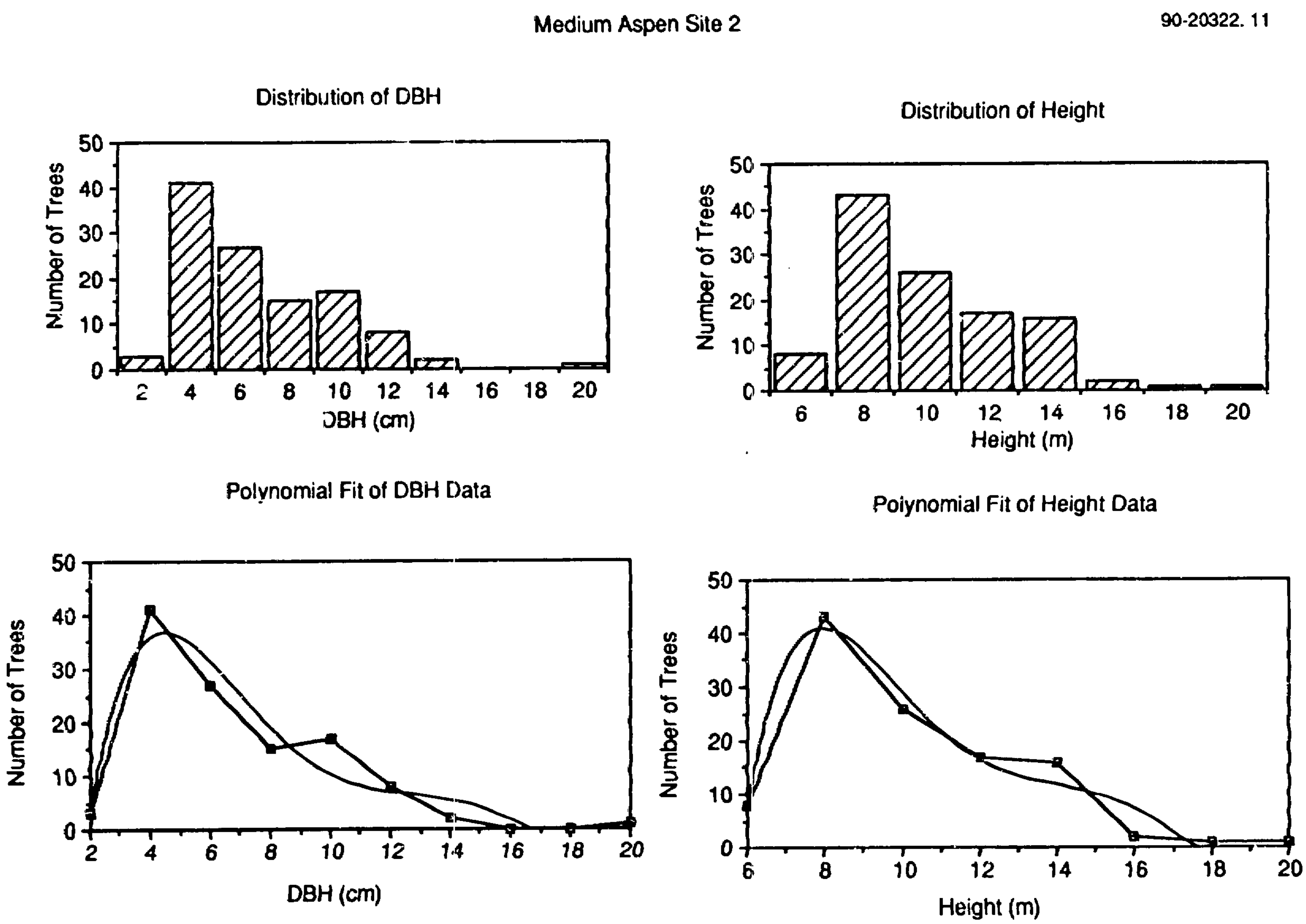


Figure 36. Histogram Plots of Diameters and Heights and PDF Curves for Medium Aspen Site 2

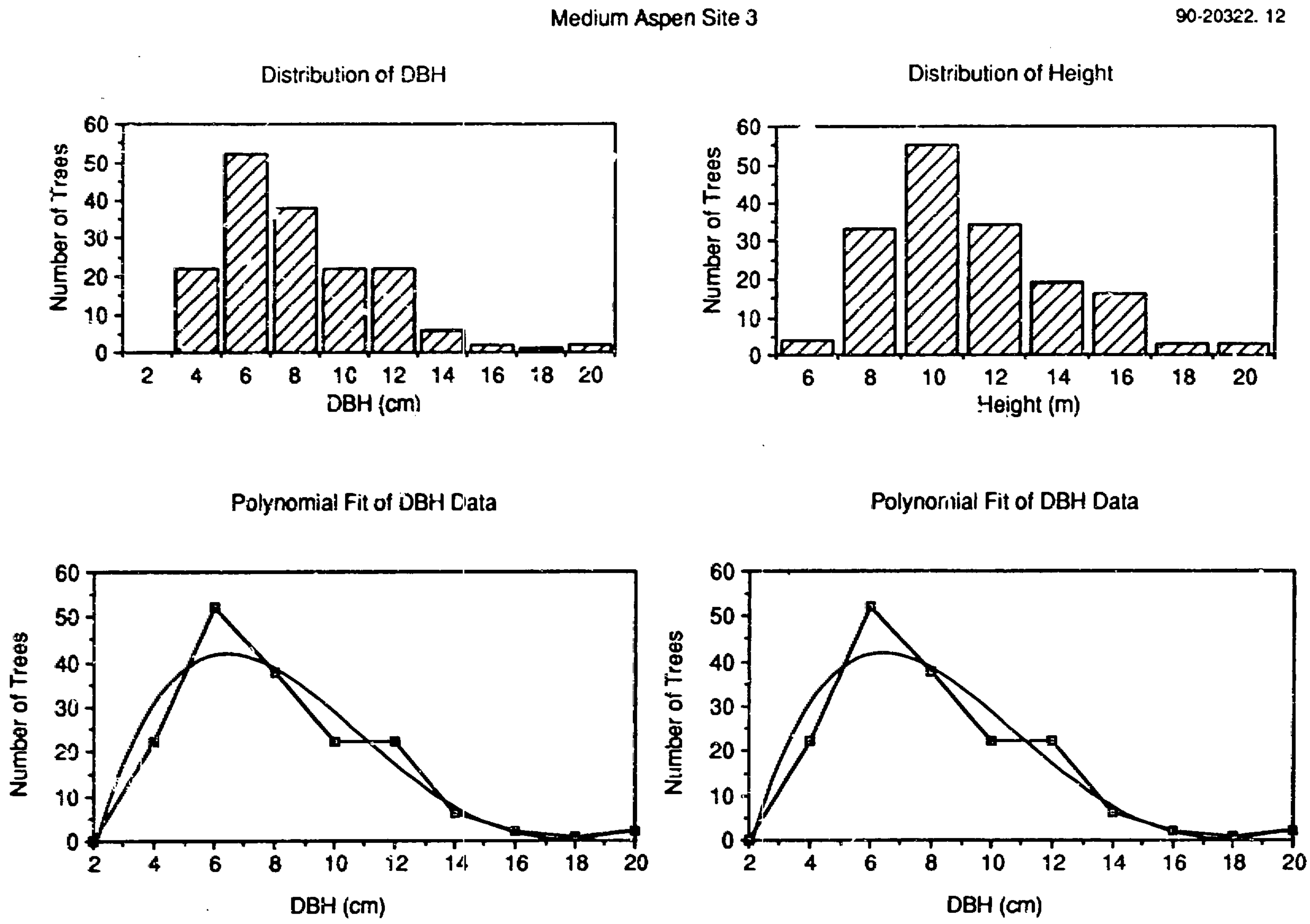


Figure 37. Histogram Plots of Diameters and Heights and PDF Curves for Medium Aspen Site 3

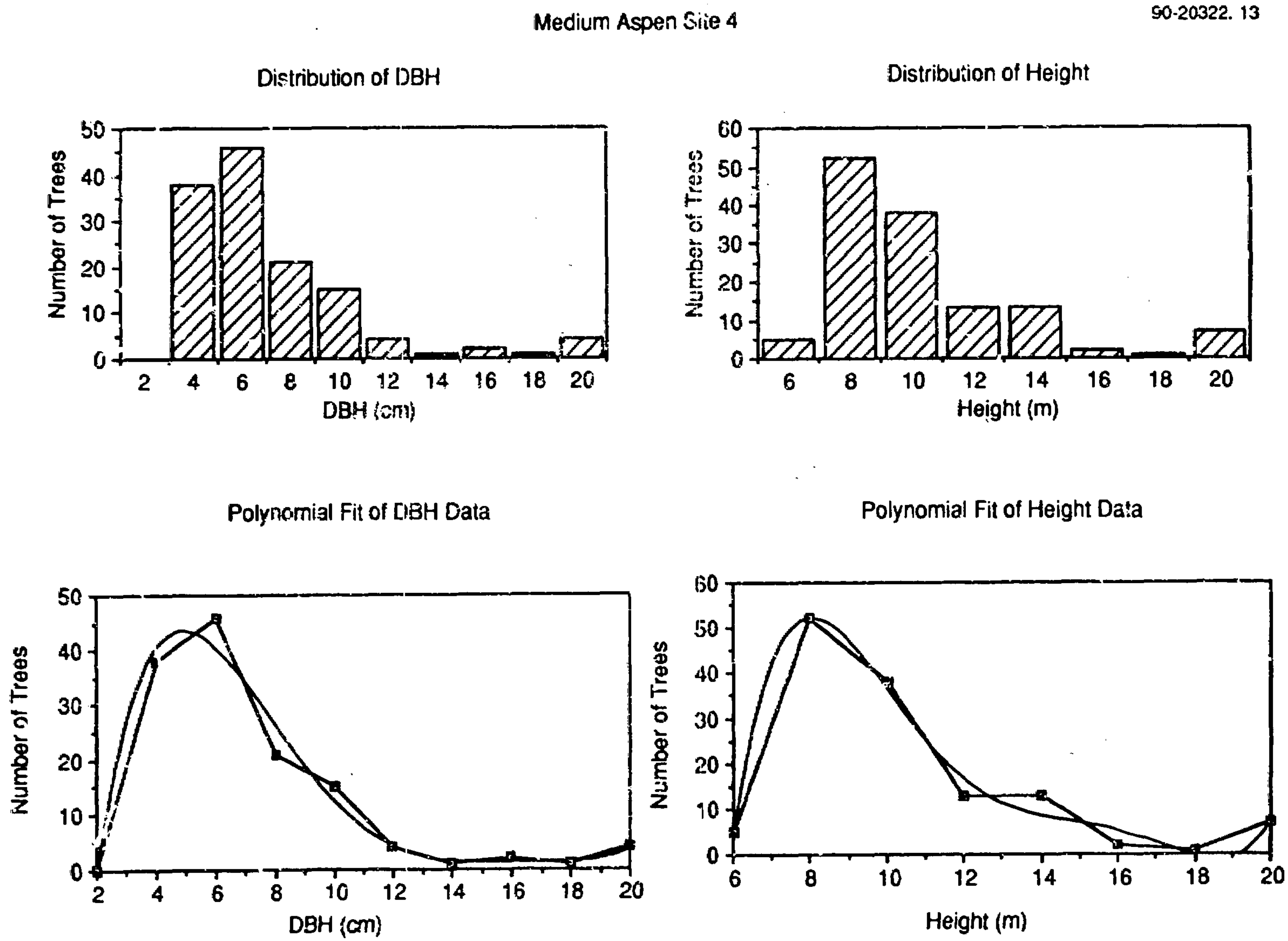


Figure 38. Histogram Plots of Diameters and Heights and PDF Curves for Medium Aspen Site 4

Medium Aspen Site 5

90-20322. 14

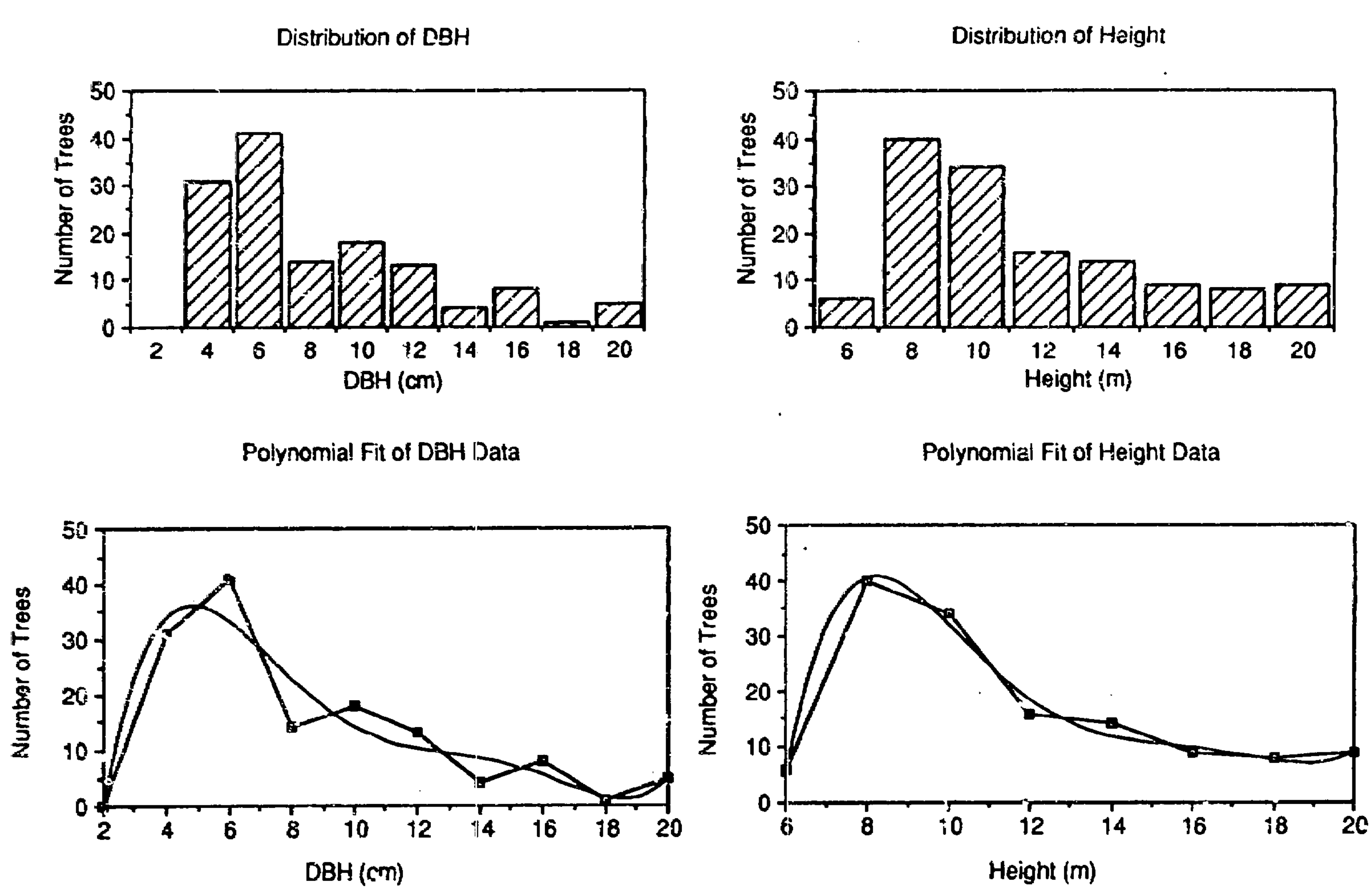


Figure 39. Histogram Plots of Diameters and Heights and PDF Curves for Medium Aspen Site 5

TABLE 10

SUMMARY OF POLYNOMIAL EQUATIONS FOR DIAMETER AND HEIGHT PDFS FOR THE MEDIUM ASPEN STAND

Entire Stand:

Diameter: x = tree diameter in cm

$$y=-308.25+228.55x-34.372x^2+1.9203x^3-3.6686e^{-2}x^4$$
$$R^2=0.955$$

Height: x = tree height in m

$$y=-5972.1+2402.3x-357.32x^2+25.604x^3-0.89714x^4+1.2370e^{-2}x^5$$
$$R^2=0.994$$

Reflector Site 1:

Diameter: x = tree diameter in cm

$$y=-40.667+41.147x-6.3950x^2+0.35820x^3-6.8109e^{-3}x^4$$
$$R^2=0.984$$

Height: x = tree height in m

$$y=-482.84+169.59x-19.106x^2+0.89134x^3-1.4974e^{-2}x^4$$
$$R^2=0.993$$

Reflector Site 2:

Diameter: x = tree diameter in cm

$$y=-112.13+90.736x-19.655x^2+1.8616x^3-8.1654e^{-2}x^4+1.3542e^{-3}x^5$$
$$R^2=0.920$$

Height: x = tree height in m

$$y=-1722.1+734.85x-117.65x^2+9.0644x^3-0.33913x^4+4.9479e^{-3}x^5$$
$$R^2=0.955$$

Reflector Site 3:

Diameter: x = tree diameter in cm

$$y=-68.000+42.826x-5.5087x^2+0.26166x^3-4.2249e^{-3}x^4$$
$$R^2=0.908$$

Height: x = tree height in m

$$y=-478.47+150.30x-15.093x^2+0.62255x^3-9.1738e^{-3}x^4$$
$$R^2=0.928$$

TABLE 10 (concluded)

SUMMARY OF POLYNOMIAL EQUATIONS FOR DIAMETER AND HEIGHT PDFS FOR THE MEDIUM ASPEN STAND

Reflector Site 4:

Diameter: x = tree diameter in cm

$$y=-125.20+92.592x-17.880x^2+1.4906x^3-5.7587e^{-2}x^4+8.4936e^{-4}x^5$$
$$R^2=0.971$$

Height: x = tree height in m

$$y=-2244.2+938.15x-146.87x^2+11.044x^3-0.40341x^4+5.7592e^{-3}x^5$$
$$R^2=0.980$$

Reflector Site 5:

Diameter: x = tree diameter in cm

$$y=-113.87+86.213x-17.736x^2+1.6150x^3-6.8641e^{-2}x^4+1.1098e^{-3}x^5$$
$$R^2=0.880$$

Height: x = tree height in m

$$y=-1374.0+561.25x-85.170x^2+6.1980x^3-0.21899x^4+3.0248e^{-3}x^5$$
$$R^2=0.986$$

3.1.1.3 Dense Aspen Stand

Table 11 summarizes the tree parameters for the different sites for the dense aspen stands. As with the medium aspen stands, the height data presented in Table 11 was derived using an allometric equation developed from field measurements, as discussed below. In comparing the medium and dense aspen stands, we note the following:

1. The average density of the trees has dropped by a factor of 2.5;
2. The average diameter of the trees has increased by a factor of two;
3. The average height of the trees has increase by approximately 60 percent; and
4. There is an increase in the number large trees other than aspen in the overstory of the canopy.

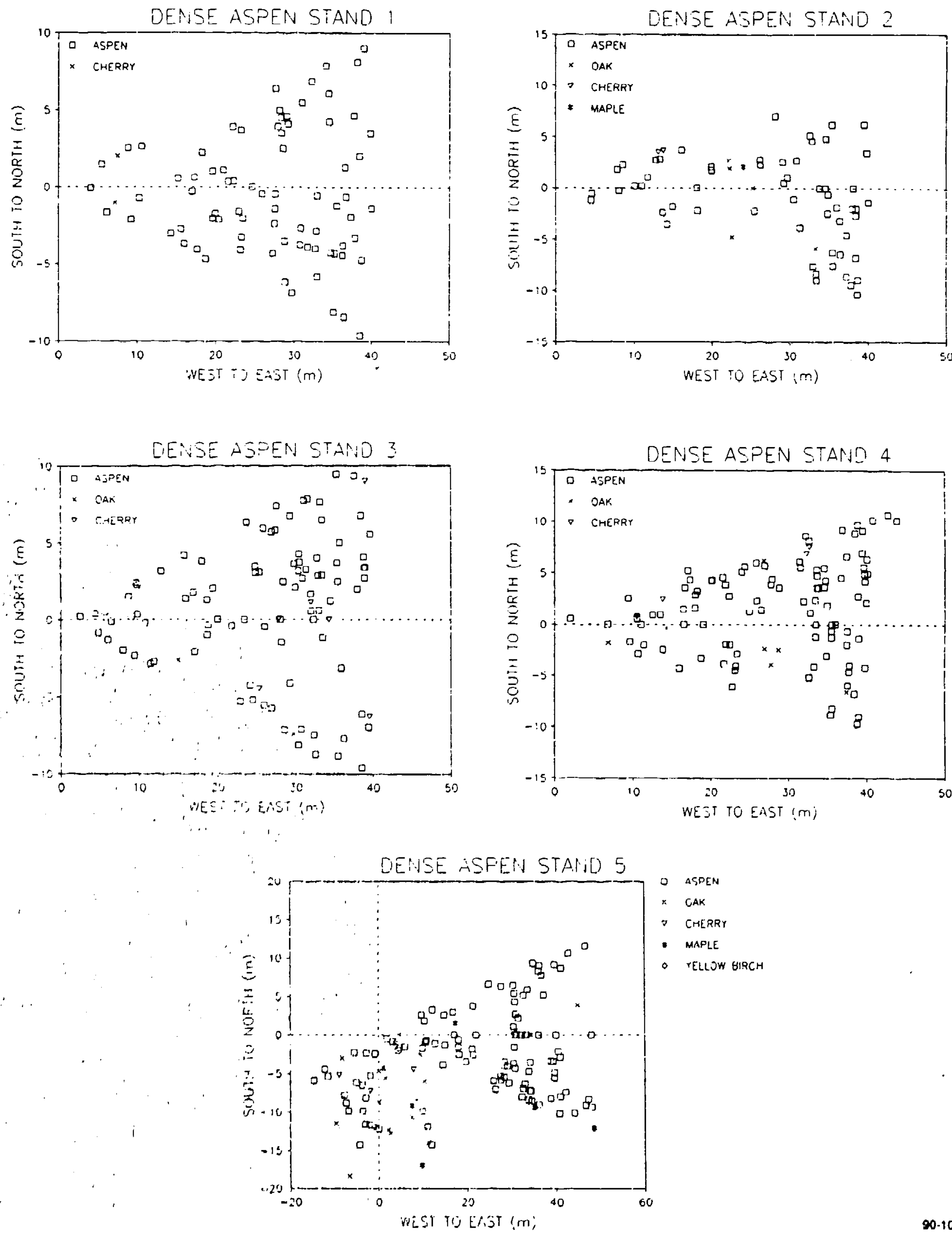
In essence, the dense aspen stand is representative of an older, more mature stand. As an aspen stand ages, trees within the stand continue to die. Up until a certain point, with the mortality of one tree, adjacent trees just grow in height or expand their canopies to fill in the gap created by the dying tree. This expansion essentially suppresses trees in the understory. However, at a certain point, there are no longer a sufficient number of aspen trees to fill in the gaps caused by mortality of an overstory tree. This results in understory trees growing into the overstory as well as a patchiness in the distribution of overstory trees while trees grow to fill in these gaps. Both of these processes are in evidence in the dense aspen stand. The patchiness of tree distribution is illustrated in Figure 40, which presents a plot of tree positions for the different dense aspen sites.

Figure 41 presents the relationship between diameter and total height and height to the lowest living branch for the dense aspen stand. Figure 42 presents the relationships between diameter and canopy depth. The regression equations developed for these relationships (eliminating several outlying points) are:

TABLE 11

SUMMARY OF DENSE ASPEN STAND MEASUREMENTS

Stand	Number of Trees	Trees per Hectare	Average Diameter (cm)	Std Dev	Average Height (m)	Std Dev
Site 1 - Entire Stand	174	1555	12.8	7.01	15.6	4.00
Site 1 - Reflector	77	1838	13.8	6.57	16.2	3.67
Site 2 - Entire Stand	146	1305	11.9	5.12	15.2	2.87
Site 2 - Reflector	57	1360	10.9	4.80	14.6	2.69
Site 3 - Entire Stand	184	1644	13.9	4.17	16.3	2.34
Site 3 - Reflector	91	1857	13.5	4.05	16.0	2.27
Site 4 - Entire Stand	172	1503	14.6	4.24	16.7	2.37
Site 4 - Reflector	98	2339	14.1	3.21	16.4	1.80
Site 5 - Entire Stand	182	1767	13.0	8.28	15.7	4.57
Site 5 - Reflector	88	2100	12.8	8.20	15.8	4.74
Site 5 - All Trees	230	2291	13.2	8.74		



90-10249

Figure 40. Plots of Tree Placement in the Dense Aspen Sites

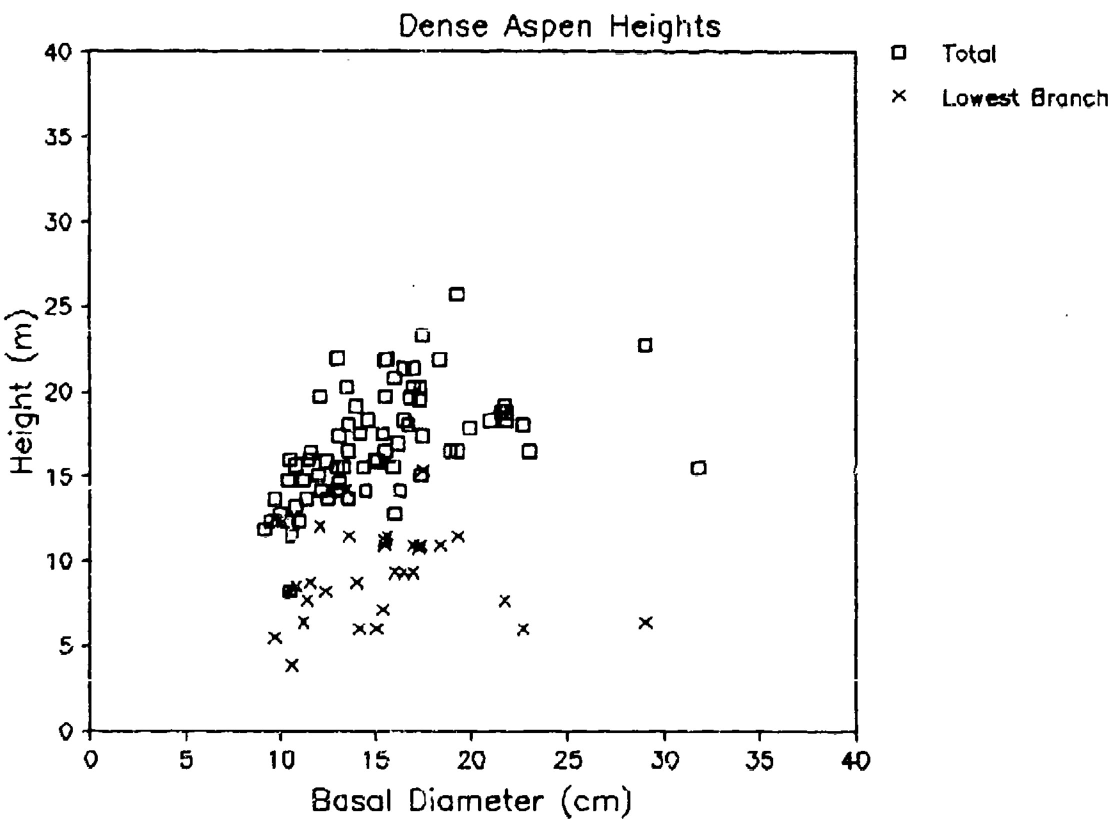


Figure 41. Relationship between Tree Diameter and Total Height and Height to Lowest Living Branch for the Dense Aspen Stand

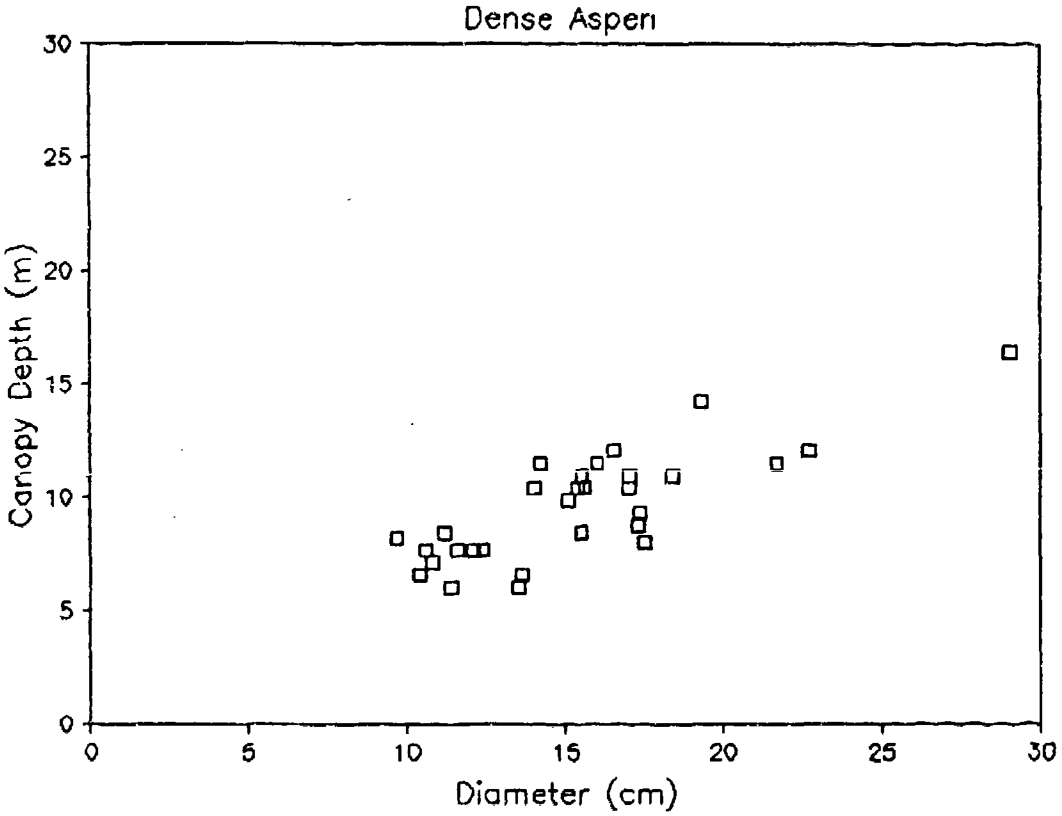


Figure 42. Relationship between Tree Diameter and Canopy Depth for the Dense Aspen Stand

Total Tree

$$Ht\ (m) = .56\ dia\ (cm) + 8.5\ (R = .59) \quad (12)$$

Lowest Living Branch

$$Ht\ (m) = .52\ dia\ (cm) + 1.8\ (R = .55) \quad (13)$$

Canopy Depth

$$C_d\ (m) = .47\ dia\ (cm) + 2.3\ (R = .81) \quad (14)$$

Finally, Figures 43 to 48 present the set of histogram and PDF curves for the dense aspen diameter and heights. The polynomial equations for the PDFs for this stand are summarized in Table 12.

3.1.2 ALLOMETRIC EQUATIONS

A variety of authors have studied the relationships between the aboveground biomass components of aspen stands. The reasons and approaches to these studies vary between authors. Therefore, the parameters from one study cannot always be directly compared to those of another. In all cases, however, the biomass relationships pertain to oven dry weights, not wet weights.

MacLean and Wein (1976) studied a series of pure jack pine and mixed hardwood stands of fire origin and age range of 7 to 57 years in northeast New Brunswick to determine biomass accumulation after fire. The region lies within the Maritime Plain, with the elevation of the gently rolling terrain ranging from 15 to 170 meters. The bedrock consists of red to grey sandstone, conglomerate, and siltstone, but almost all the upland areas are overlain with glacial till.

The allometric equations for quaking aspen (Populus tremuloides) for this study are:

Total Biomass

$$\text{Log } Y = -0.790 + 2.070 \text{ Log (dia)} \quad (15)$$

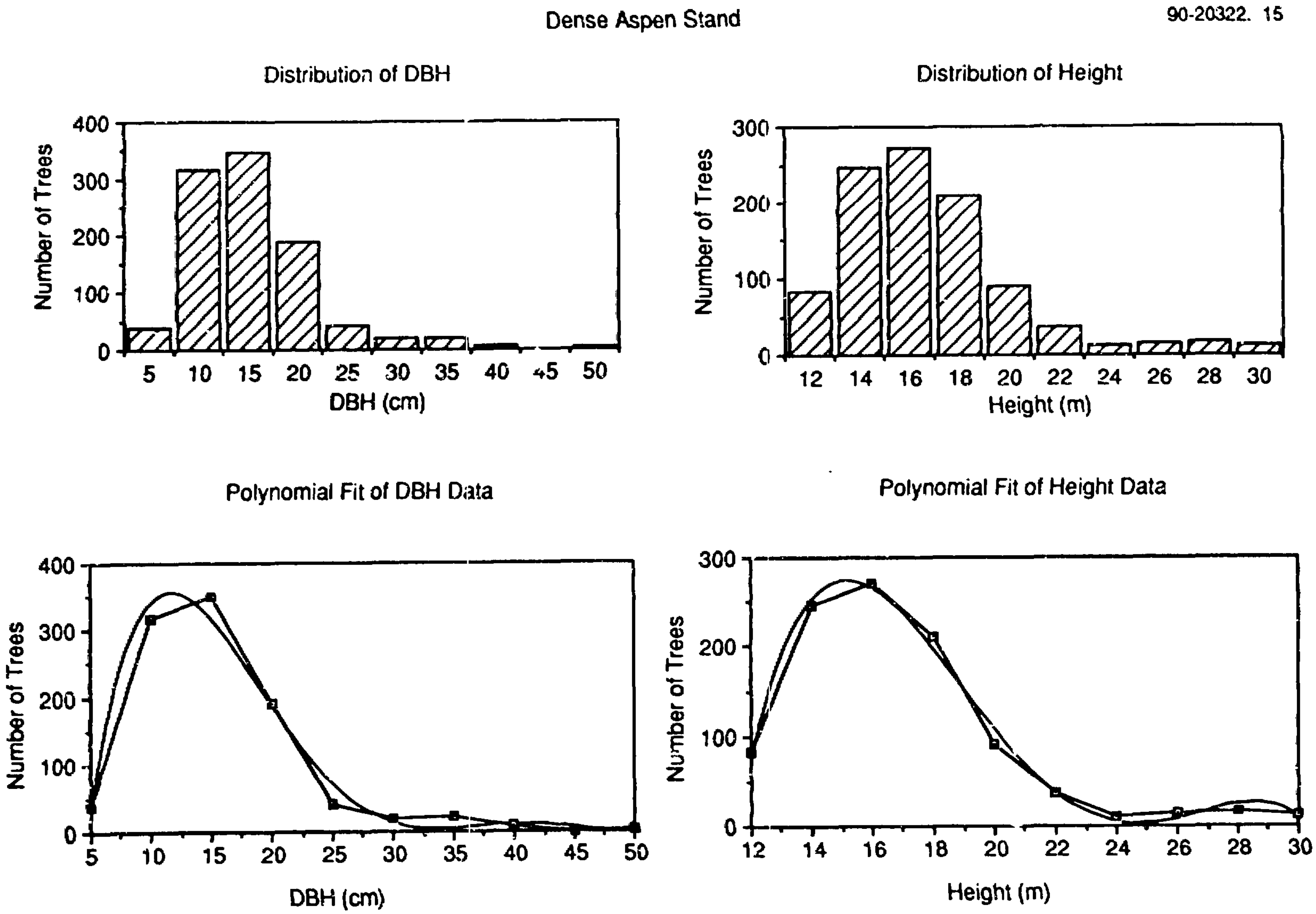


Figure 43. Histogram Plots of Diameters and Heights and PDF Curves for All Dense Aspen Sites Combined

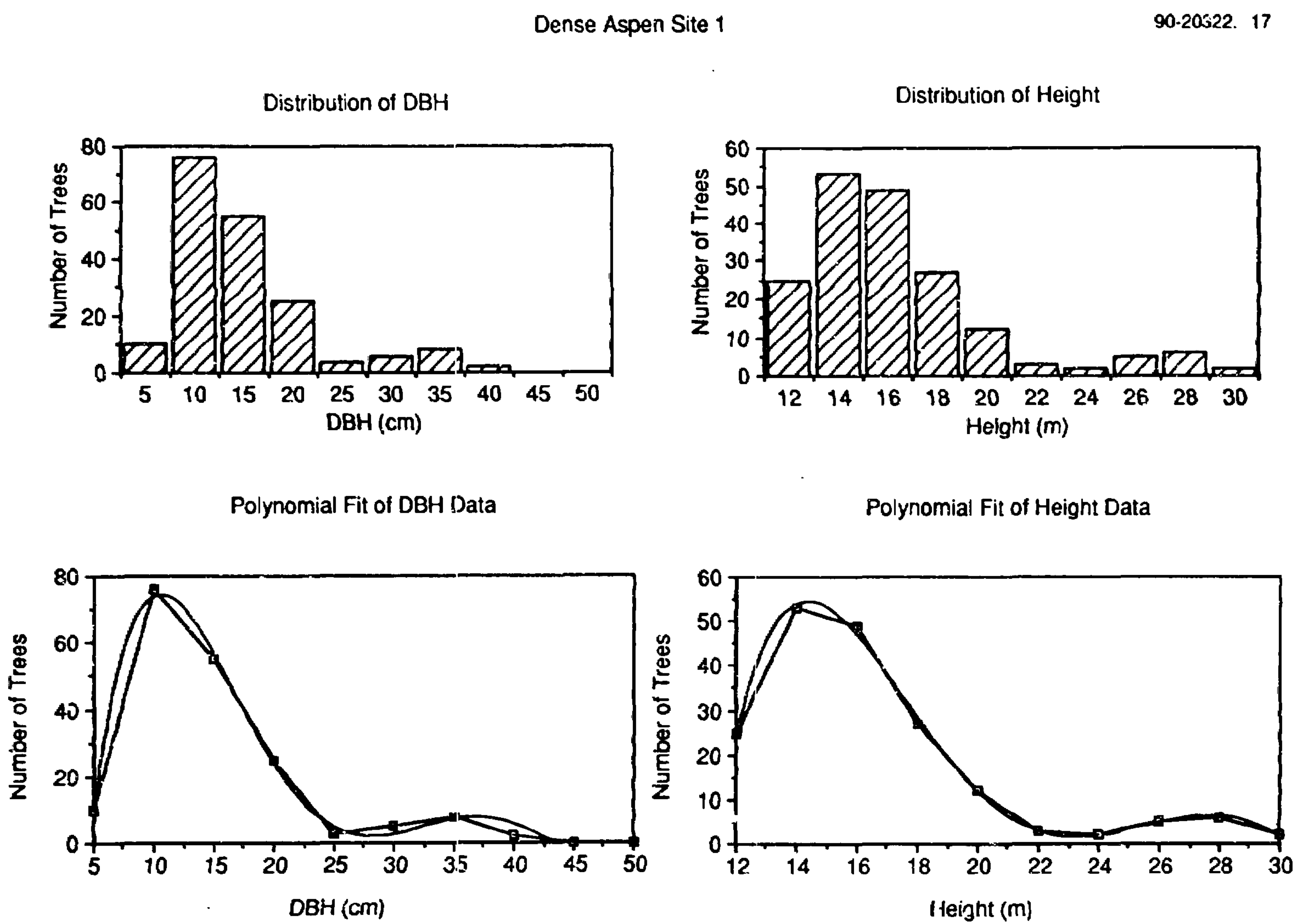


Figure 44. Histogram Plots of Diameters and Heights and PDF Curves for Dense Aspen Site 1

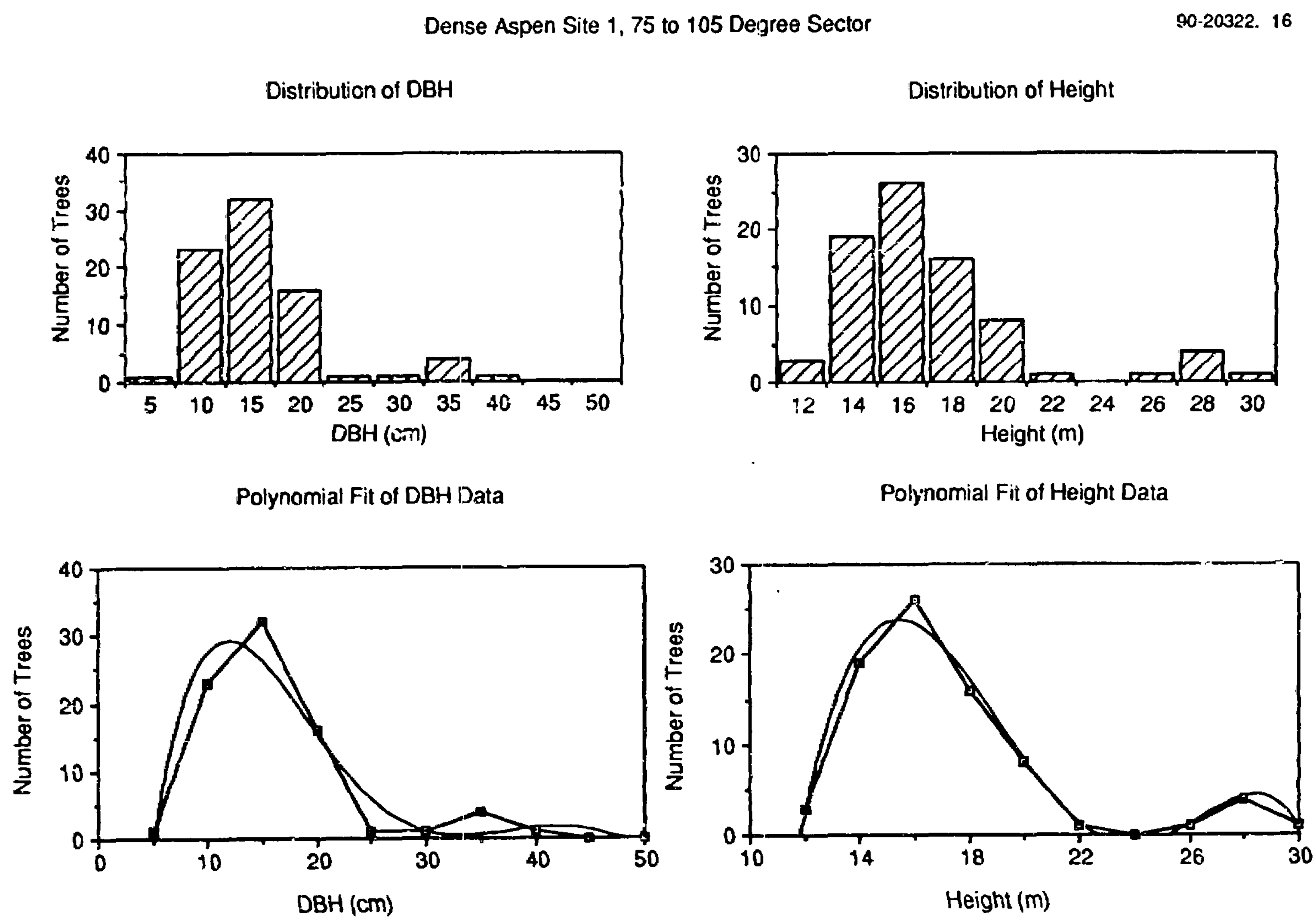


Figure 44 concluded. Histogram Plots of Diameters and Heights and PDF Curves for Dense Aspen Site 1.

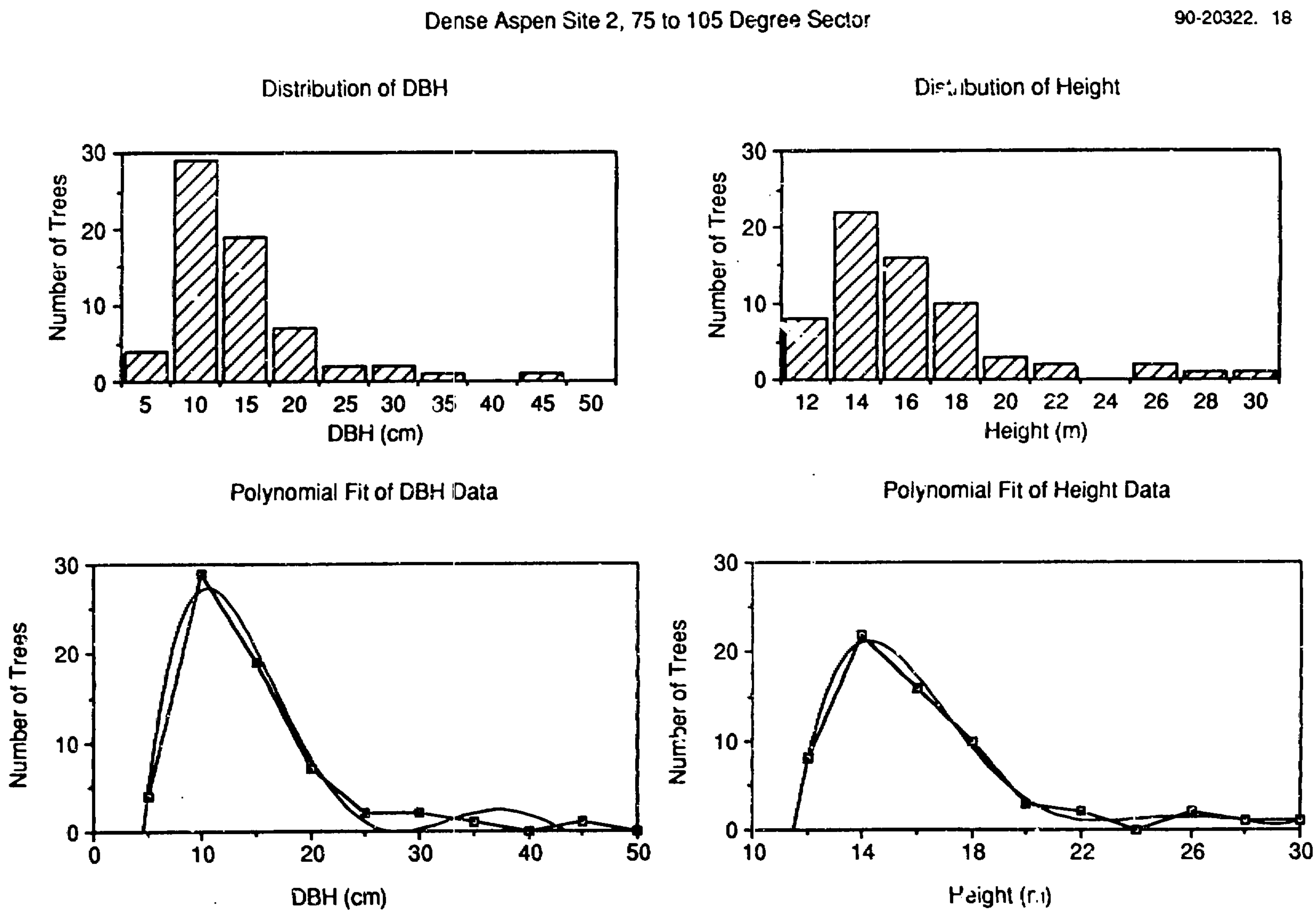


Figure 45. Histogram Plots of Diameters and Heights and PDF Curves for Dense Aspen Site 2

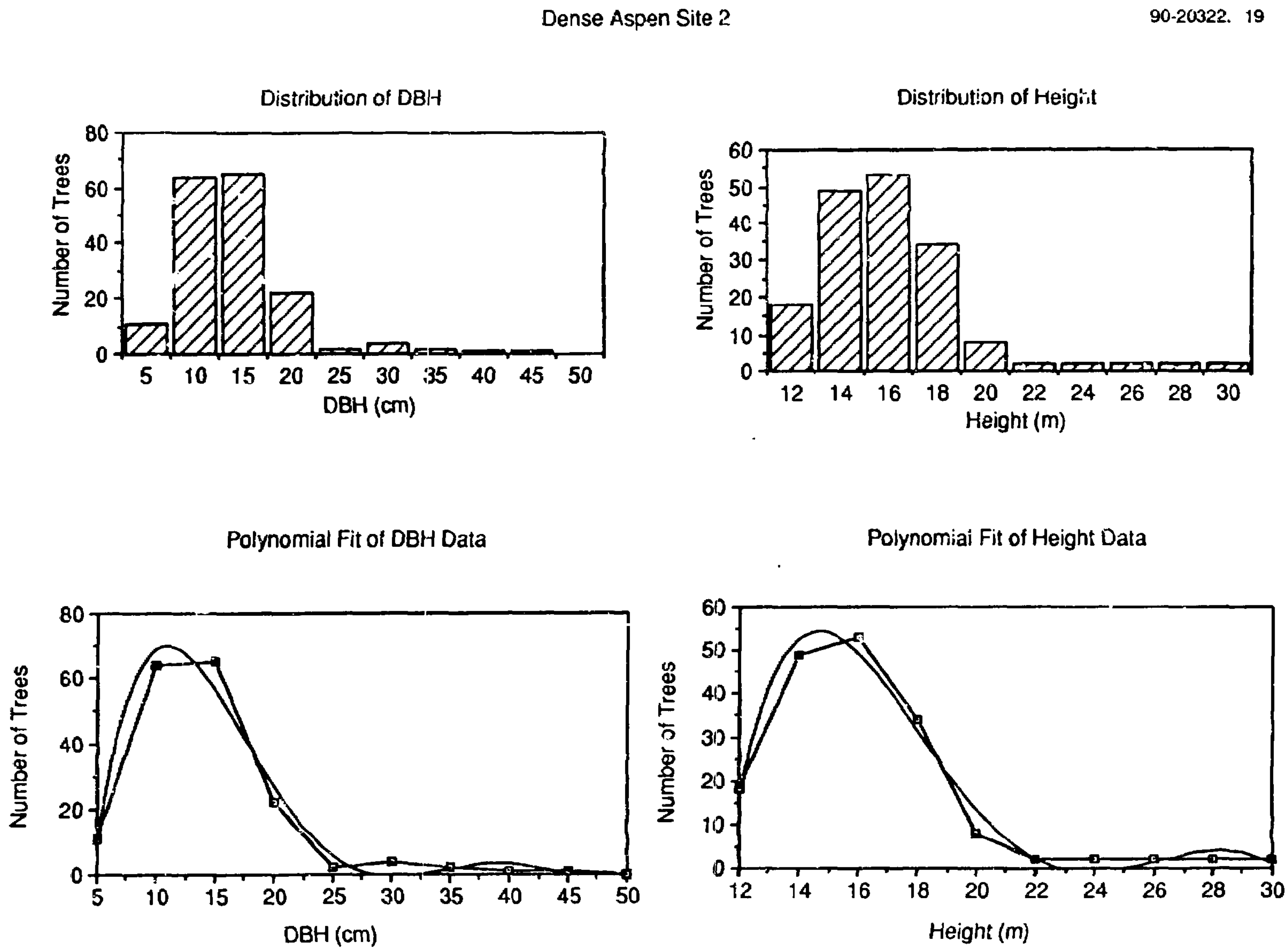


Figure 45 concluded. Histogram Plots of Diameters and Heights and PDF Curves for Dense Aspen Site 2.

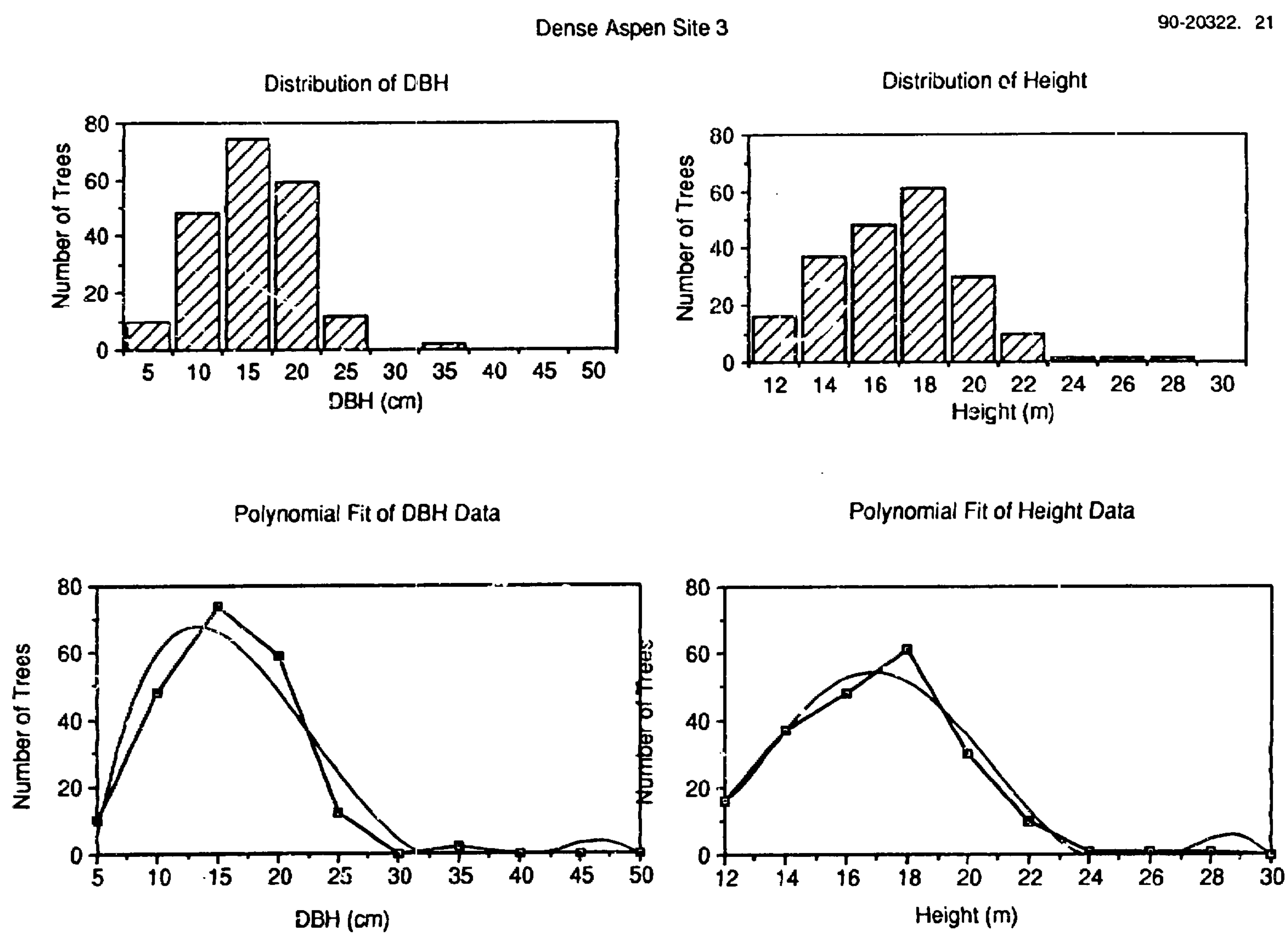


Figure 46. Histogram Plots of Diameters and Heights and PDF Curves for Dense Aspen Site 3

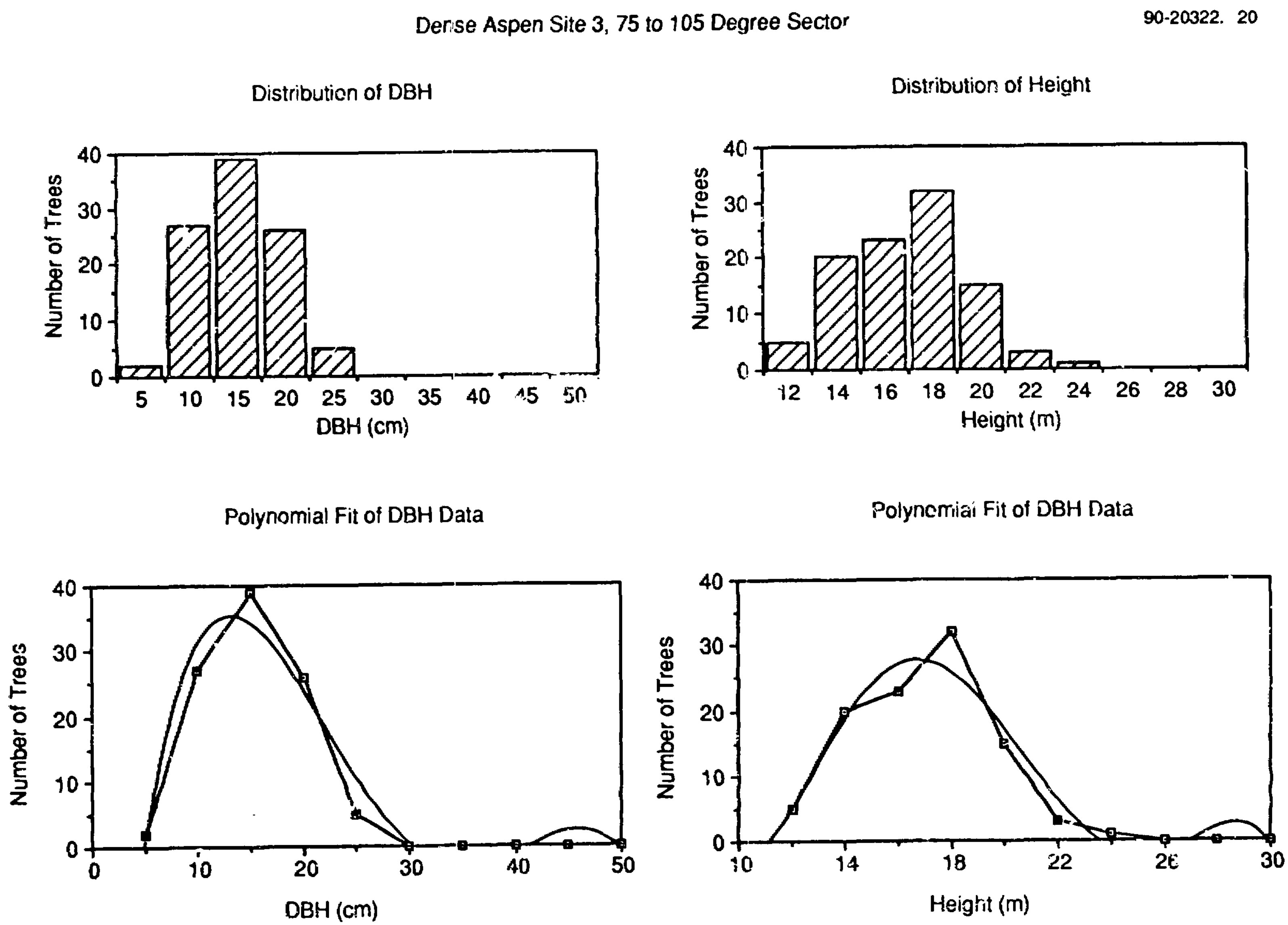


Figure 46 concluded. Histogram Plots of Diameters and Heights and PDF Curves for Dense Aspen Site 3.

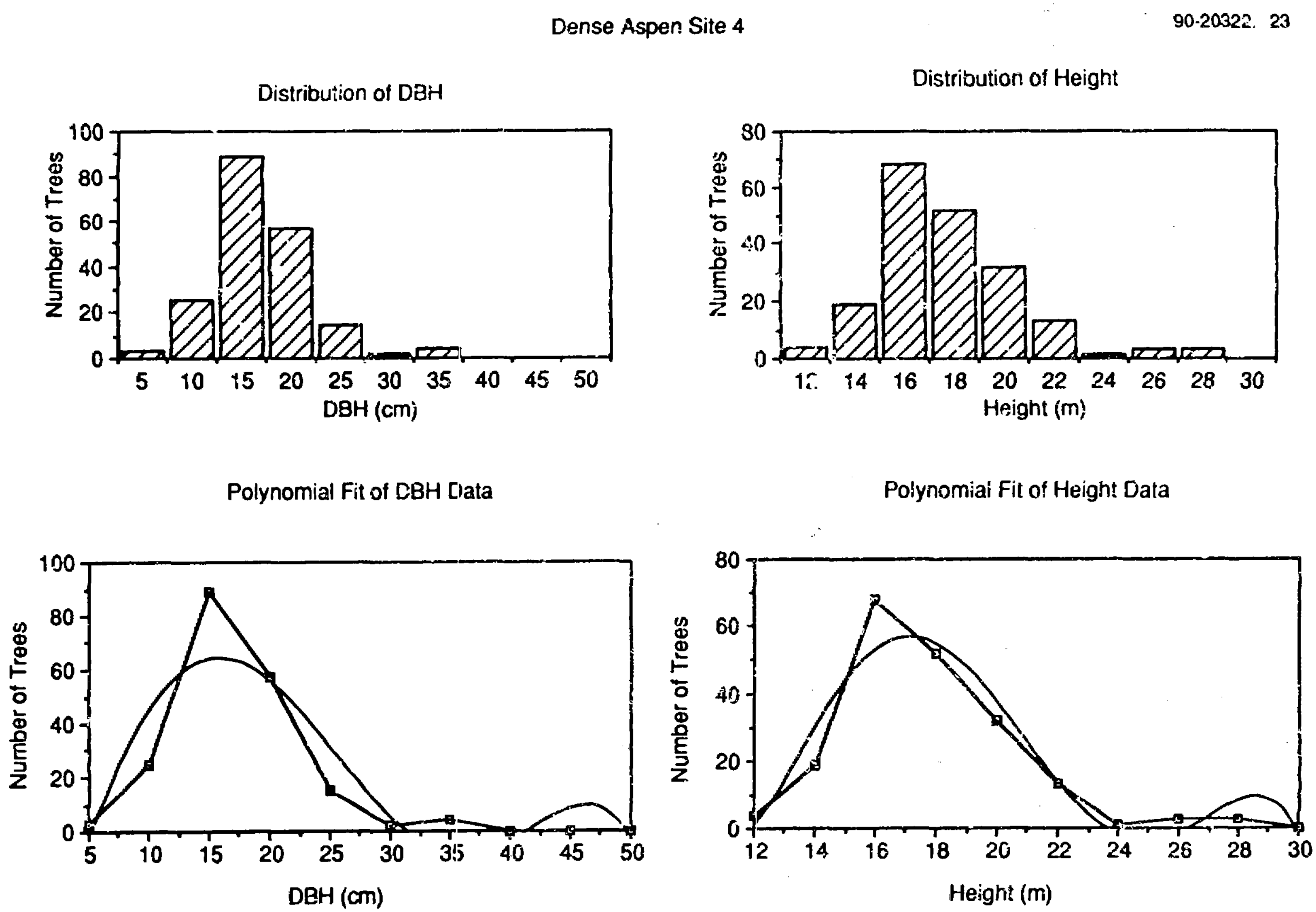


Figure 47. Histogram Plots of Diameters and Heights and PDF Curves for Dense Aspen Site 4

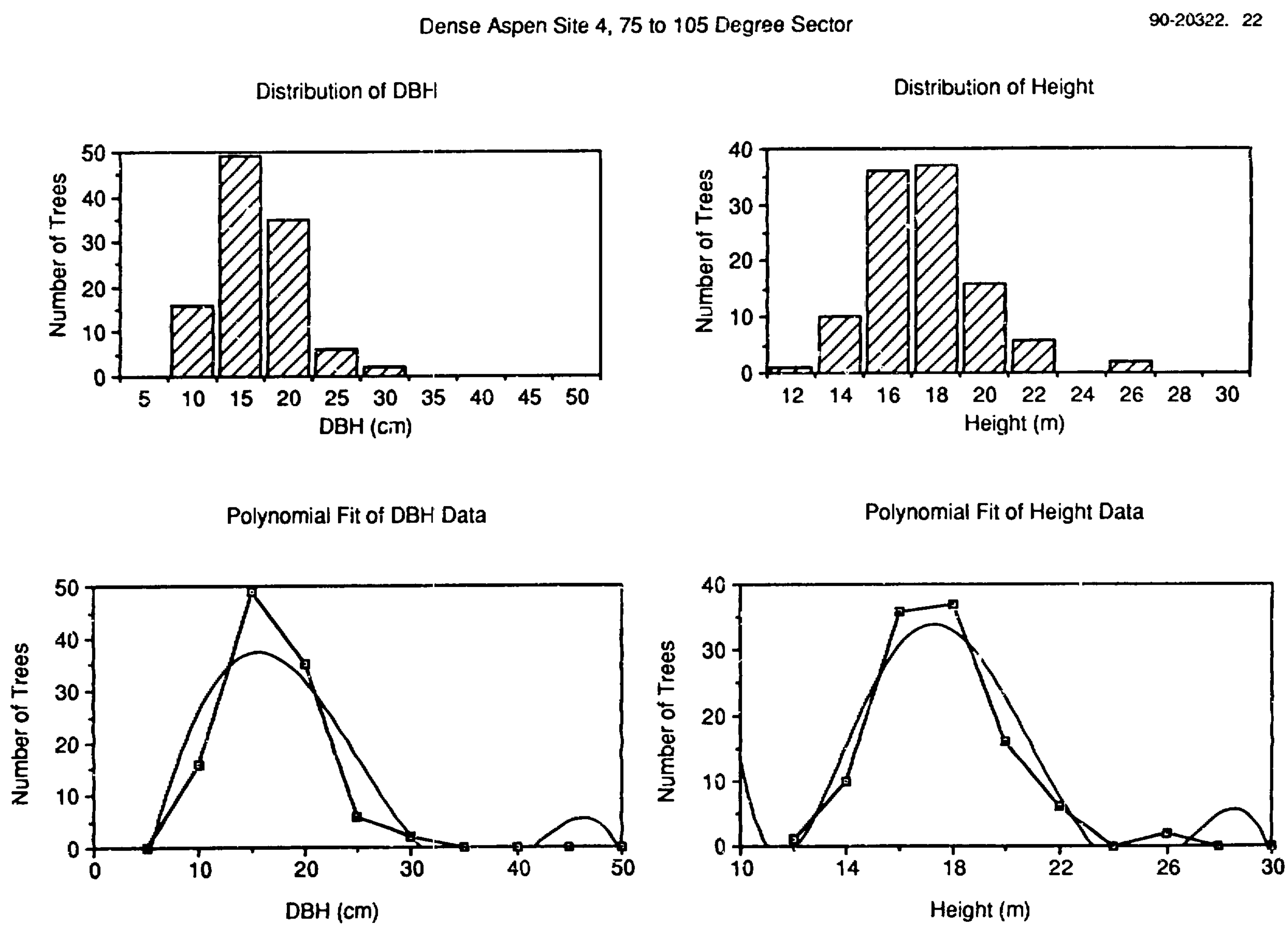


Figure 47 concluded. Histogram Plots of Diameters and Heights and PDF Curves for Dense Aspen Site 4.

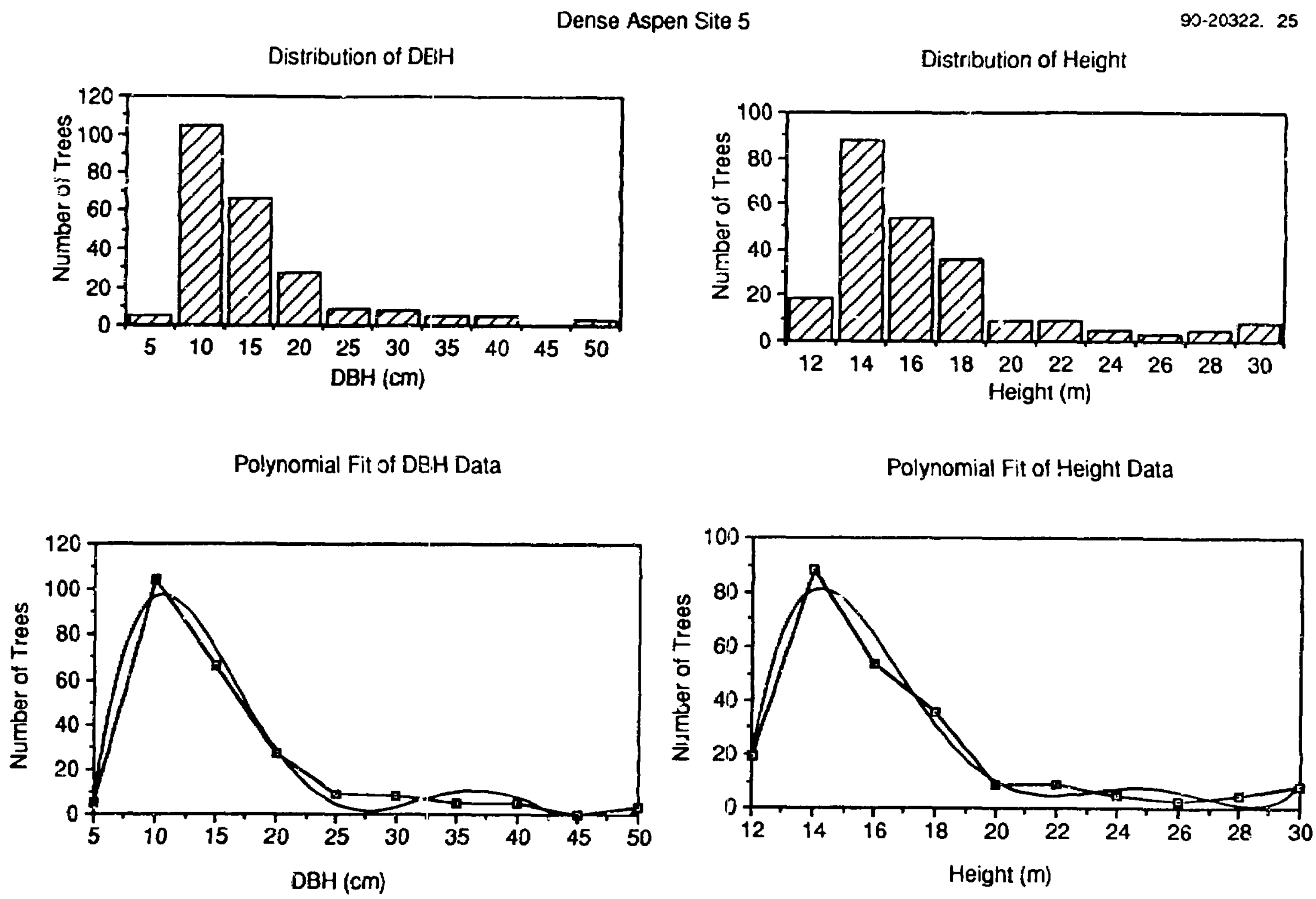


Figure 48. Histogram Plots of Diameters and Heights and PDF Curves for Dense Aspen Site 5

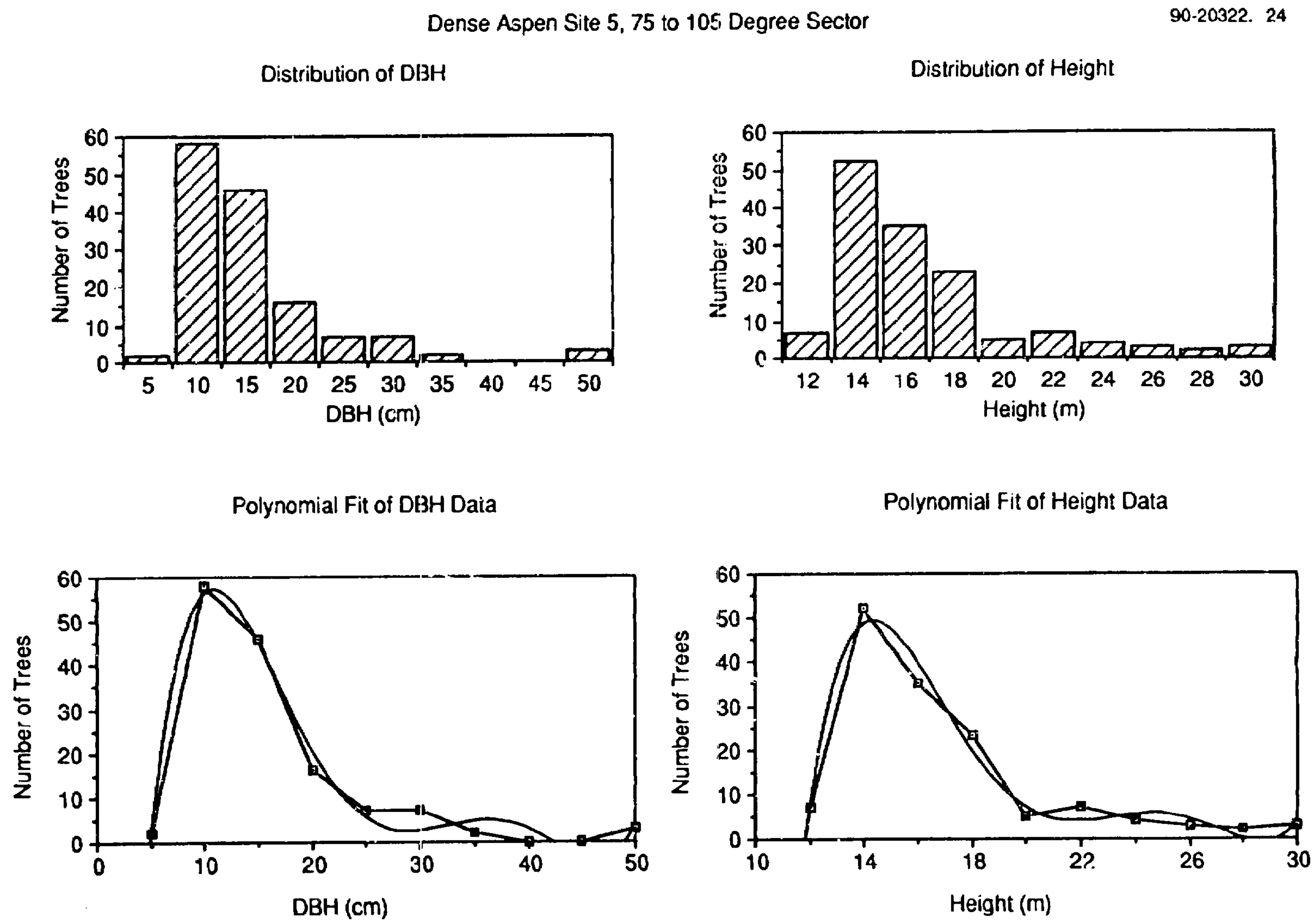


Figure 48 concluded. Histogram Plots of Diameters and Heights and PDF Curves for Dense Aspen Site 5.

TABLE 12
SUMMARY OF POLYNOMIAL EQUATIONS FOR DIAMETER AND HEIGHT
PDFS FOR THE DENSE ASPEN STAND

Entire Stand:

Diameter: x = tree diameter in cm

$$y=-983.60+306.47x-24.508x^2+0.83565x^3-1.3052e^{-x4}+7.6964e^{-5}x^5$$
$$R^2=0.982$$

Height: x = tree height in m

$$y=-1.1596e^4+2339.1x-164.82x^2+4.9720x^3-5.4533e^{-2}x^4$$
$$R^2=0.993$$

Reflector Site 1:

All trees

Diameter: x = tree diameter in cm

$$y=-251.60+82.882x-7.3868x_2+0.28174x^3-4.8945e^{-3}x^4+3.1836e^{-5}x^5$$
$$R^2=0.993$$

Height: x = tree height in m

$$y=-4165.7+972.67x-85.923x_+3.6379x^3-7.4341e^{-2}x^4+5.8894e^{-4}x^5$$
$$R^2=0.998$$

75 to 105 degree sector

Diameter: x = tree diameter in cm

$$y=-88.800+26.572x-2.0952x^2+7.0551e^{-2}x^3-1.0852e^{-3}x^4+6.2769e^{-6}x^5$$
$$R^2=0.923$$

Height: x = tree height in m

$$y=-714.89+107.18x-2.8801x^2-0.21565x^3+1.2711e^{-2}x^4-1.8029e^{-4}x^5$$
$$R^2=0.983$$

Reflector Site 2:

All trees

Diameter: x = tree diameter in cm

$$y=-212.07+68.984x-5.9043x^2+0.21517x^3-3.5755e^{-3}x^4+2.2318e^{-5}x^5$$
$$R^2=0.973$$

Height: x = tree height in m

$$y=-4078.5+927.66x-79.643x^2+3.2688x^3-6.4572e^{-2}x^4+4.9279e^{-4}x^5$$
$$R^2=0.980$$

TABLE 12 (continued)

SUMMARY OF POLYNOMIAL EQUATIONS FOR DIAMETER AND HEIGHT PDFS FOR THE DENSE ASPEN STAND

Reflector Site 2:

75 to 105 degree sector

Diameter: x = tree diameter in cm

$$y=-90.467+30.106x-2.6947x^2+0.10287x^3-1.7864e^{-3}x^4+1.1610e^{-5}x^5$$
$R^2=0.977$

Height: x = tree height in m

$$y=-2436.7+594.33x-55.670x^2+2.5301x^3-5.6148e^{-2}x^4+4.8878e^{-4}x^5$$
$R^2=0.989$

Reflector Site 3:

All trees

Diameter: x = tree diameter in cm

$$y=-125.25+36.351x-2.2598x^2+5.1873e^{-2}x^3-4.0443e^{-4}x^4$$
$R^2=0.925$

Height: x = tree height in m

$$y=3922.4-1144.8x+127.76x^2-6.7794x^3+0.17194x^4-1.6787e^{-3}x^5$$
$R^2=0.958$

75 to 105 degree sector

Diameter: x = tree diameter in cm

$$y=-76.600+21.634x-1.3922x^2+3.4045e^{-2}x^3-3.0751e^{-4}x^4+4.5128e^{-7}x^5$$
$R^2=0.953$

Height: x = tree height in m

$$y=1503.0-462.48x+53.591x^2-2.9180x^3+7.5350e^{-2}x^4-7.4519e^{-4}x^5$$
$R^2=0.933$

TABLE 12 (concluded)
SUMMARY OF POLYNOMIAL EQUATIONS FOR DIAMETER AND HEIGHT
PDFS FOR THE DENSE ASPEN STAND

Reflector Site 4:

All trees

Diameter: x = tree diameter in cm

$$y=-60.867+10.686x+0.52666x^2-7.1653e^{-2}x^3+2.0036e^{-3}x^4-1.7149e^{-5}x^5$$
$$R^2=0.813$$

Height: x = tree height in m

$$y=5036.9-1474.8x+164.44x^2-8.7196x^3+0.22124x^4-2.1635e^{-3}x^5$$
$$R^2=0.912$$

75 to 105 degree sector

Diameter: x = tree diameter in cm

$$y=-41.600+7.6568x+0.18964x^2-3.7626e^{-2}x^3+1.1018e^{-3}x^4-9.6000e^{-6}x^5$$
$$R^2=0.840$$

Height: x = tree height in m

$$y=3621.1-1041.7x+114.53x^2-6.0095x^3+0.15128x^4-1.4704e^{-3}x^5$$
$$R^2=0.911$$

Reflector Site 5:

All trees

Diameter: x = tree diameter in cm

$$y=-363.33+117.30x-10.505x^2+0.40421x^3-7.0900e^{-3}x^4+4.6564e^{-5}x^5$$
$$R^2=0.981$$

Height: x = tree height in m

$$y=-1.2502e^4+3098.6x-296.63x^2+13.823x^3-0.31511x^4+2.8205e^{-3}x^5$$
$$R^2=0.968$$

75 to 105 degree sector

Diameter: x = tree diameter in cm

$$y=-209.13+66.503x-5.8543x^2+0.22248x^3-3.8736e^{-3}x^4+2.5354e^{-5}x^5$$
$$R^2=0.981$$

Height: x = tree height in m

$$y=-8021.6+1981.6x-189.27x^2+8.8044x^3-0.20040x^4+1.7909e^{-3}x^5$$
$$R^2=0.976$$

Bole Biomass

$$\text{Log } Y = -1.0067 + 2.1426 \text{ Log (dia)} \quad (16)$$

Crown Biomass

$$\text{Log } Y = -1.250 + 1.940 \text{ Log (dia)} \quad (17)$$

where Y is the biomass in 10^4 kg/ha and dia = diameter at breast height (1.5 m above the ground) in cm, and the crown layer includes branches and leaves.

Zavitkovski (1971) studied four aspen stands in northern Wisconsin to determine the dry weights of various tree components. The database consisted of Populus tremuloides and Populus grandidentata trees of age 6 to 45 years. They developed allometric relations for aspen between: 1) an index of volume (diameter x height) as the independent variable and dry weights of foliage, live branches, dead branches, and total live tree as dependent variables: and 2) diameter at crown base to dry weights of crown and foliage. The following equations were developed:

Foliage

$$\text{Log } Y = -2.260 + 0.674 \text{ Log IV} \quad (18)$$

$$\text{Log } Y = -2.031 + 2.242 \text{ Log (dia)} \quad (19)$$

Crown

$$\text{Log } Y = -1.764 + 2.716 \text{ Log (dia)} \quad (20)$$

Live branches

$$\text{Log } Y = -2.535 + 0.943 \text{ Log IV} \quad (21)$$

Dead branches

$$\text{Log } Y = -2.757 + 0.728 \text{ Log IV} \quad (22)$$

Total live tree

$$\text{Log } Y = -1.688 + 0.990 \text{ Log IV} \quad (23)$$

where Y = biomass (Kg), dia = diameter (cm), and IV = $(\text{dia})^2$ x Ht (height in m).

Finally, Isebrands and Nelson (1982) studied branch morphology and the distribution of leaves and specific leaf weight in five and six year old Populus 'tristis' grown in northern Wisconsin under short rotation intensive culture at 1.2 and .6 square meter spacings. They developed the following allometric equations relating the product of diameter and height to leaf area per tree as well as relating leaf area per tree to total aboveground biomass:

5 year old trees

$$LA = 16419 + 274.72\ IV \tag{24}$$

6 year old trees

$$LA = 15123 + 155.88\ IV \tag{25}$$

$$TAB = 194.18 + 0.0604\ LA \tag{26}$$

where LA = leaf area per tree in square cm, IV is the same as defined above, except diameters are measured, and TAB = total aboveground biomass (kg per tree).

3.2 JACK PINE STANDS

In this section, we will first summarize the measurements obtained for the jack pine stands, and then discuss allometric equations which are available in the scientific literature.

3.2.1 Geometric Measurements

The same basic stand measurements (tree placement, diameter, height, etc.) which were made for the aspen stands were also obtained for the jack pine stands. The measurement strategy for these stands, although similar to those used in the aspen stands, was somewhat different because of the basic characteristics of the jack pines.

The sparse and medium jack pine stands were actually plantations of small trees. These plantations had a definite row structure, and were of a low enough density that individual trees could be easily sampled. For these stands, all trees within a specified distance from the target location were measured for placement and diameter. The areas measured are illustrated in Figure 49. For the sparse jack pine site, two sets of measurements were obtained. One set of measurements were obtained when the corner reflectors were aligned for a radar look direction of 225° (i.e., for the first 2 ALP missions), while the second set measurements were taken when the corner reflectors were aligned for a 270° radar look direction. For the 225° degree samples, the heights of all trees were measured using a calibrated staff along with the diameters of the trees. For the 270° measurements, only the diameters were measured. An additional sub-sample of 20 trees were measured for diameter, total height, and height to the lowest living branch. Finally, branches were harvested from several trees to examine biomass relationships.

For the medium jack pine stands, height measurements using the calibrated staff were obtained for a limited subsample of approximately 90 trees, 20 of which were sampled for height to the lowest living

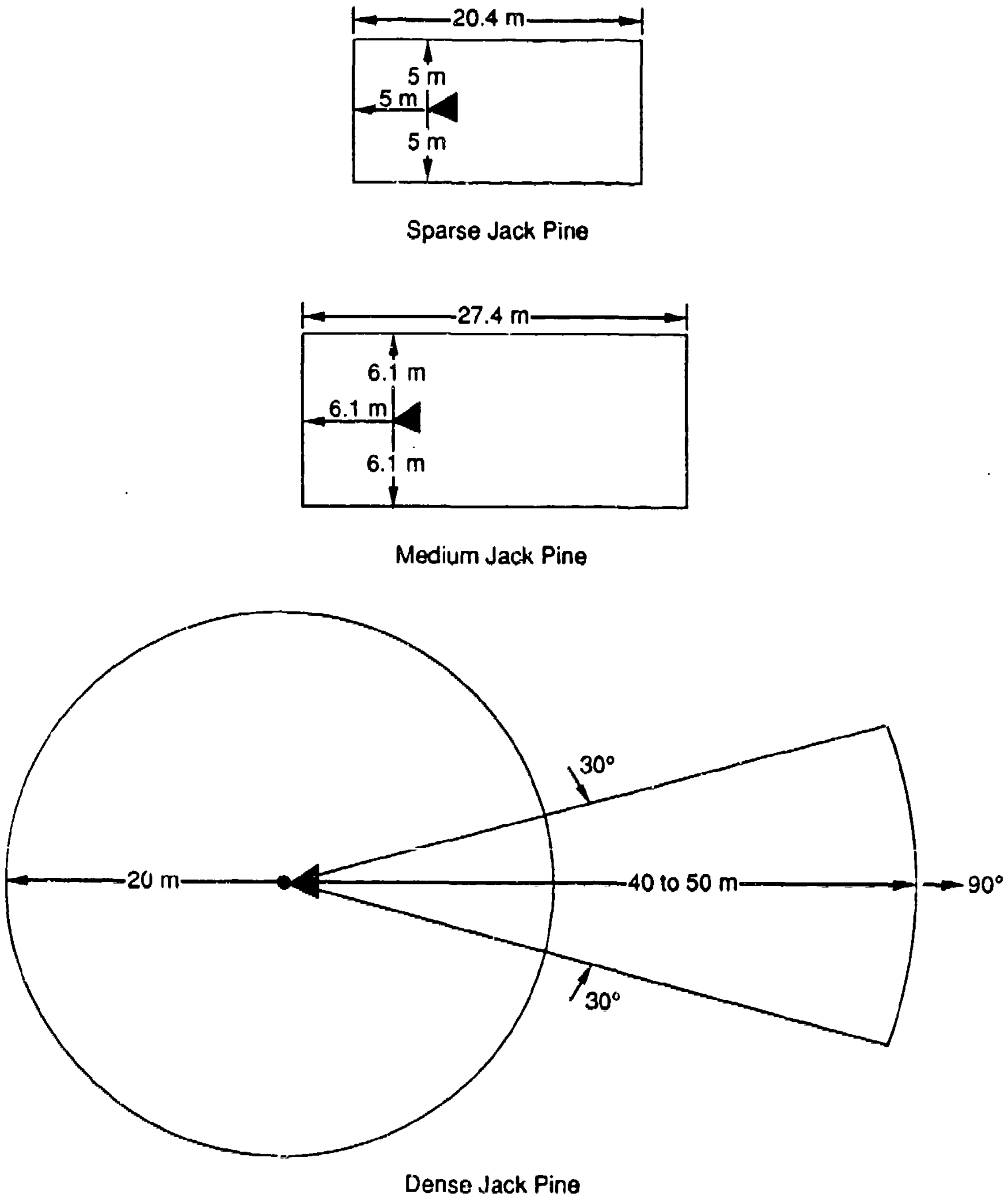


Figure 49. Illustrations of Areas Sampled for the Jack Pine Stands

branch. Diameters of all trees within the sample area were obained, along with the relative position to each tree.

Finally, for the dense jack pine stands, the distance, heading and diameter and species of all trees which fell within a 30° arc with a radius of 50 m were recorded. The diameters were measured to the nearest 0.1 cm. The 30° arc was centered at a heading of 90°. Outside of this arc, all trees within 20 m of the target were sampled in an identical fashion. A total of 41 trees were measured for diameter, total height, and height to the lowest living branch. The height measurements were made using a Reloscope.

3.2.1.1 Sparse Jack Pine Data

Table 13 summarizes the tree measurements for the sparse jack pine stands. The between stand variation was fairly small, with the exception of Site 6. Figure 50 presents a plot of diameter versus total height and height to the lowest living branch for this stand. This plot shows that while a linear relationship exists between diameter and total height, height to the lowest living branch seems to be fairly constant (average height to lowest living branch = 0.75 m). With elimination of those points where dia = 1 cm and Ht < 1.1m , the regression equation for total height as a function of diameter is

$$Ht\ (m) = 1.78 + .29\ dia\ (cm) \quad (R = .82) \tag{27}$$

During the most recent trip to Camp Ripley in November 1989, a total of six different branches were sampled from the sparse and medium aspen stands in order to determine their biomass characteristics. Tables 14 and 15 summarize the biomass measurements made from these samples. In addition, several photographs of sparse and medium jack pine trees were analyzed. These photographs are presented in Figure 51. Measurements from these photographs included the length and angles of all first order branches. These measurements are summarized in Table 16.

TABLE 13

SUMMARY OF SPARSE JACK PINE STAND MEASUREMENTS

225° LOOK DIRECTION SITE

Site	Total Trees	Trees per Hectare	Diameter Average	Diameter Std Dev	Height Average	Height Std dev
1	21	1050	6.3	1.79	4.0	.71
2	29	1450	5.4	2.11	3.1	.65
3	26	1300	6.5	2.04	3.3	.70
4	24	1200	7.2	2.31	4.0	.75
5	24	1400	6.4	2.69	6.3	1.00
6	41	2050	3.3	2.72	2.3	1.29
Total	165	1408	5.6	2.72	3.25	1.13

270° LOOK DIRECTION SITE

Site	Total Trees	Trees per Hectare	Diameter Average	Diameter Std Dev	Height* Average	Height* Std dev
1	25	1000	6.4	1.54	3.6	.42
2	46	1840	5.2	2.18	3.2	.68
3	36	1440	6.1	1.84	3.5	.54
4	35	1400	6.8	2.04	3.7	.54
5	38	1520	6.6	2.12	3.6	.62
6	22	880	5.5	2.22	2.8	.92
Total	202	1616	6.1	2.11	3.4	.73

*Based on heights predicted by allometric equation

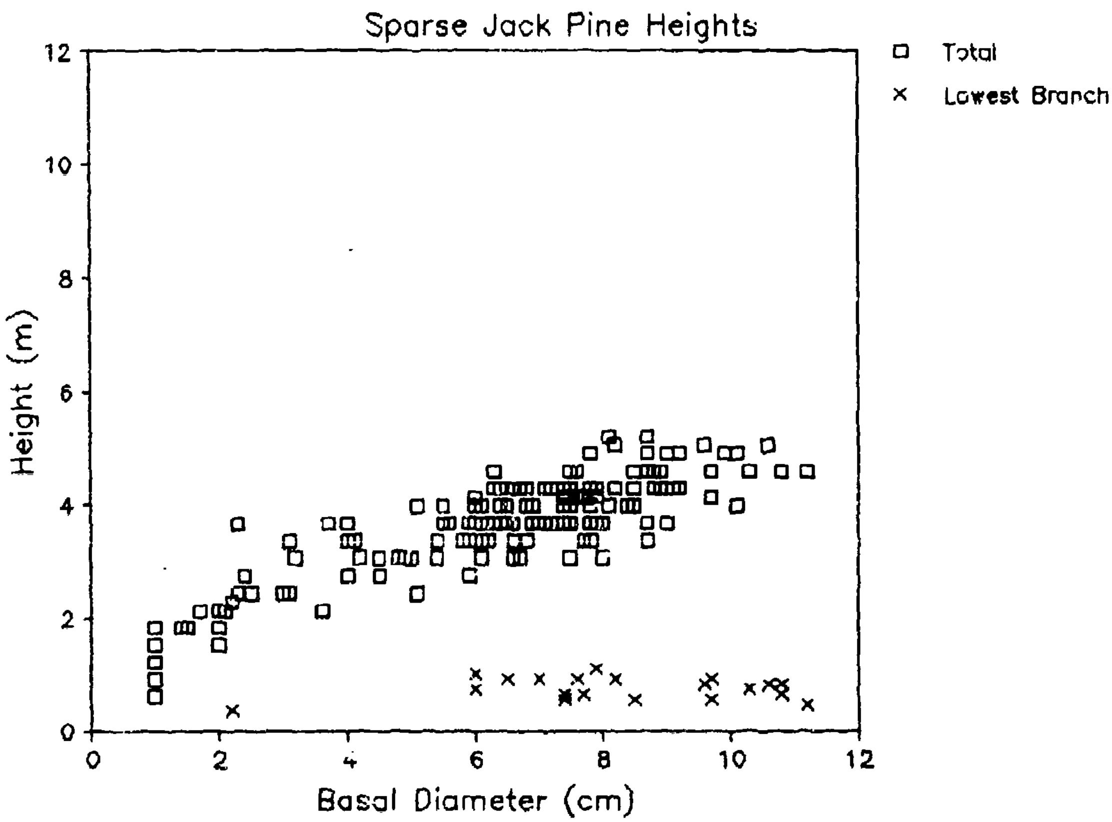


Figure 50. Plot of Tree Diameter versus Total Tree Height and Height to Lowest Living Branch for Sparse Jack Pine Stands

TABLE 14

SUMMARY OF JACK PINE BIOMASS MEASUREMENTS

Branch Number	Diameter (cm)	Length (cm)	Volume Index	Branch Number 2nd Order	Branch Number 3rd Order
Sparse Jack Pine					
1	1.8	134	434	35	62
2	1.7	77	223	14	34
3	1.2	82	118	6	23
4	3.2	173	1772	59	90
Medium Jack Pine					
1	3	230	2070	32	39
2	2.4	170	979	39	34
3	2.4	190	1094	50	24

Branch Number	Dry Weight (gms) Branch	2nd Order	3rd Order	Needles	Cones	Total
Sparse Jack Pine						
1	63.77	22.27	6	89.02	29.5	211.02
2	44.42	15.88	6	67.97	39.71	174.22
3	19.29	9.85	2	35.38	27.07	93.36
4	194.6	107.64	48	246.7	55.64	652.87
Medium Jack Pine						
1	338.9	81.54	26	70.84	16.89	533.77
2	164.6	77.29	32	62.9	0	336.99

TABLE 15

SUMMARY OF SECONDARY AND TERTIARY BRANCH DIAMETER AND LENGTH MEASUREMENTS FOR SPARSE AND MEDIUM JACK PINES

2ND ORDER BRANCHES

	Sparse Pine		Medium Pine	
	Diameter (cm)	Length (cm)	Diameter (cm)	Length (cm)
	.5	25.8	.92	34.3
	.4	26.7	.65	39.3
	.53	29.6	1.1	50.5
	.47	21.2	.7	21.2
	.49	29.4	.66	35
	.34	15.7	.45	32.6
	.42	18.3	.5	32.7
	.68	41.8	.7	35.7
	.4	21.4	.45	35.5
	.57	25.2	.5	16.7
	.4	14.9	.71	58.7
	.64	34.6		
	.5	43.5		
	.43	24.5		
	.3	15.3		
	.25	14.1		
	.31	13.7		
	.21	15.2		
	.31	14.6		
	.51	37.6		
	1	87		
	.97	49.8		
	.86	62.8		
	.87	55.3		
	.72	55.6		
Average	.52	31.7	.67	35.7
Std Dev	.22	18.25	.19	11.09

TABLE 15 (concluded)
SUMMARY OF SECONDARY AND TERITARY BRANCH DIAMETER AND LENGTH FOR SPARSE AND MEDIUM JACK PINES

3RD ORDER BRANCHES

	Sparse Pine Diameter (cm)	Sparse Pine Length (cm)	Medium Pine Diameter (cm)	Medium Pine Length (cm)
	.28	14.1	.3	23.8
	.26	14.4	.37	27.3
	.24	13.6	.15	37.5
	.29	15.8	.5	32.8
	.2	10.9	.38	25.5
	.21	8.4	.47	33.4
	.21	7.9	.4	38.7
	.26	15.2	.32	20.6
	.44	15.7	.38	17.7
	.37	21.8	.31	26.6
	.34	14.3	.29	25.6
	.38	21.1	.38	34.7
	.38	14.2	.48	28.7
	.39	22.5	.42	26.9
	.3	16.1	.44	30
	.33	11.4	.48	25.2
	.22	11.1	.29	27.2
	.3	7.5	.3	17.9
	.21	11.2	.3	23.2
	.2	6.5	.37	26
	.44	5.3		
	.22	7.1		
	.2	7.2		
	.19	7.9		
	.21	5.7		
	.21	7.1		
	.22	6.6		
	.2	9		
	.18	4.8		
	.43	21.1		
	.45	18.4		
	.42	31.6		
	.39	23.4		
	.37	18.1		
	.3	11.6		
	.25	13.2		
	.3	24.7		
	.35	29.3		
	.24	17.5		
Average	.29	13.93	.37	27.47
Std Dev	.08	6.67	.08	5.62

90-10248

88-12161-7A

88-12161-6A

Sparse Jack Pine

88-12161-00

Medium Jack Pine

Figure 51. Surface Photographs of Sample Trees from Sparse and Medium Jack Pine Stands

TABLE 16

SUMMARY OF BRANCH LENGTH AND ANGLE MEASUREMENTS FROM SMALL JACK PINE TREES

Tree	Angle	Estimated Length (cm)
Sparse 1	32.0	127
	31.5	153
	40.0	126
	34.5	130
	38.2	74
	50.5	156
	38.0	86
	52.5	60
	58.0	53
	35.5	94
	52.0	131
	41.0	
	37.0	
	39.0	
Average	41.4	108
Std Dev	8.1	34.6
Sparse 2	49.0	153
	9.8	86
	28.0	196
	50.5	116
	50.0	174
	32.0	123
	40.0	
	40.0	
	36.0	
	54.5	
	48.0	
	59.0	
	54.0	
	45.5	
Average	42.6	141
Std Dev	12.5	37.3

TABLE 16 (concluded)

SUMMARY OF BRANCH LENGTH AND ANGLE
MEASUREMENTS FROM SMALL JACK PINE TREES

Tree	Angle	Estimated Length (cm)
Medium 1	26.0	148
	26.5	129
	36.5	128
	61.0	122
	43.0	142
	58.0	172
	67.0	
	62.0	
	54.5	
	45.0	
Average	48.0	140
Std Dev	14.1	16.7

The combination of these data should allow us to construct an average tree profile for the sparse jack pine stand (as well as the medium jack pine stand discussed in the next section). Figure 52 presents the histograms and PDF curves for the branch length and angle measurements. The angle measured in this case was the angle between the tree trunk and the branch. From Table 16, we can see that while the average angle for the medium jack pine was larger than that measured for the sparse jack pines, the average branch lengths were the same in one example and less for the sparse jack pine for the other. Finally, the total number of branches for each tree in the photographs were estimated, although branch length and angle measurements could not be obtained for each one. The sparse jack pine trees had an average of 33 branches per tree, while the medium jack pine tree had an estimated 45 branches

Figure 53 presents a plot of branch diameter versus length for all the samples taken. A linear regression of diameter as a function of branch length reveals the following relationship:

$$\text{dia (cm)} = .59 + .0109\ L\ \text{(cm)} \quad (R = .86) \tag{28}$$

where L is the branch length. Thus, based on the branch length PDFs predicted in Figure 52 and Eq. (28), a PDF for the branch diameters can also be derived.

In Table 14, we present a parameter volume index (VI), which can be calculated as

$$VI = L\ (\text{dia})^2 \tag{29}$$

This parameter essentially is a means of combining diameter and length into a single parameter. In Figure 54, we present a plot of the number of second order branches as a function of volume index. Using a logarithmic transformation of VI, we obtain the following relationship

$$\text{no. 2nd order branches} = 33.485\ \text{Log (VI)} - 60.4 \quad (R = .84) \tag{30}$$

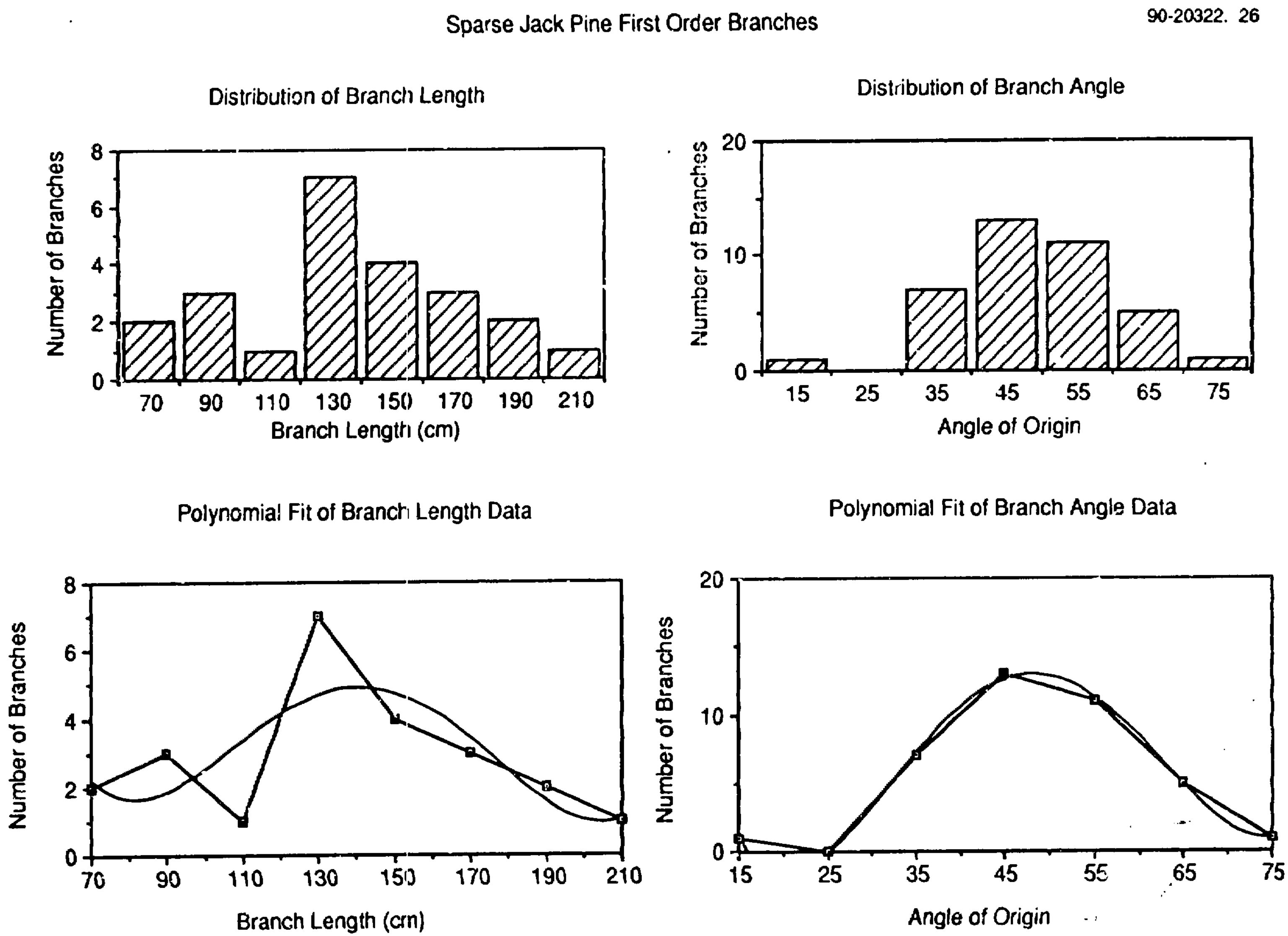


Figure 52. Plot of Histograms of Branch Angle and Branch Length and PDF Curves for the Sparse Jack Pine Trees

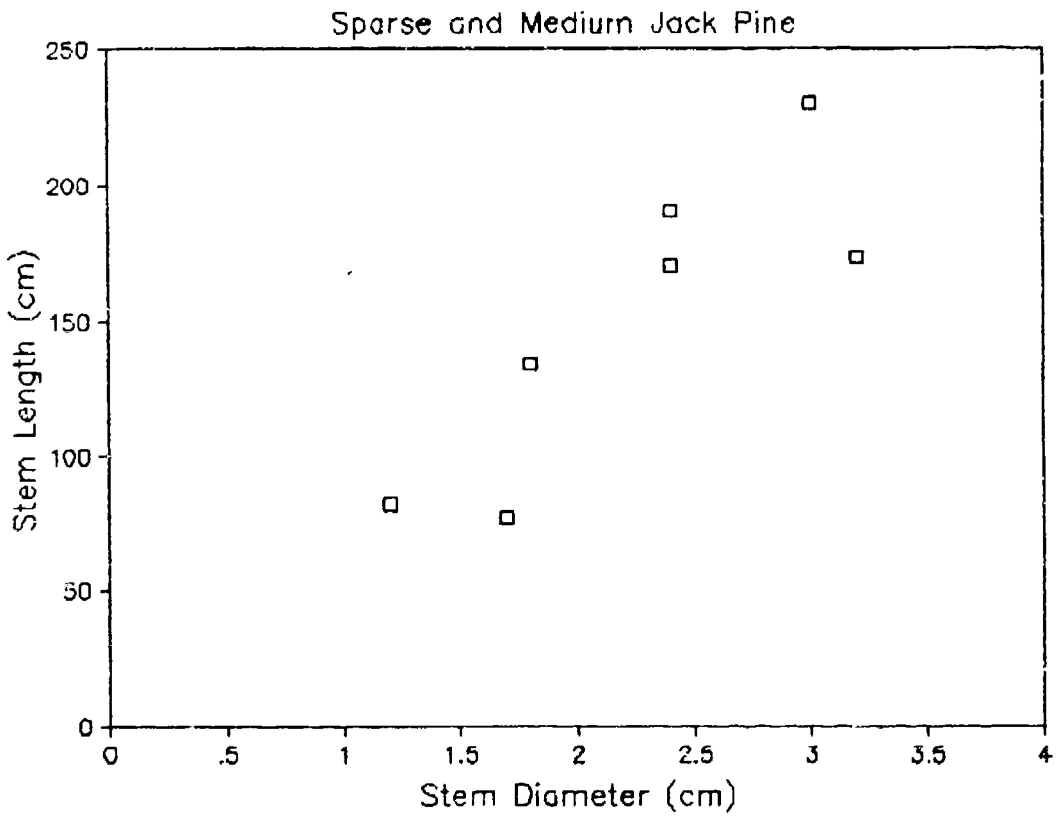


Figure 53. Relationship between Branch Diameter and Length for Sparse and Medium Jack Pine Samples

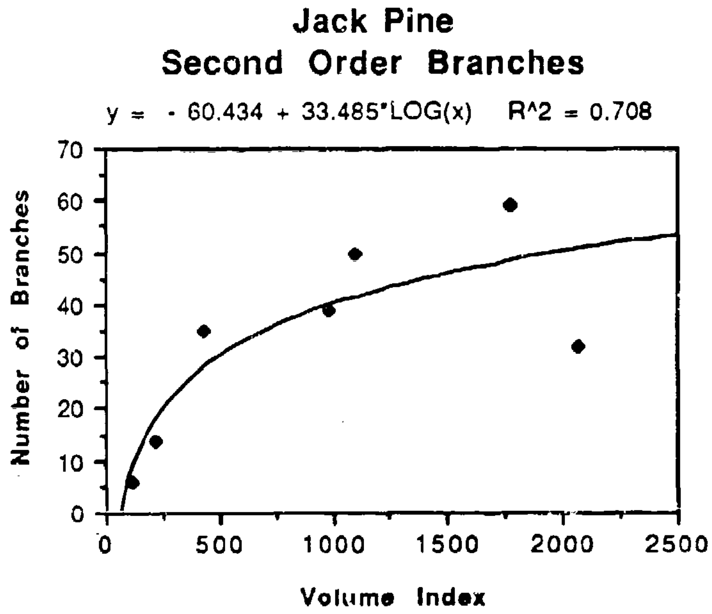


Figure 54. Plot of Number of Second Order Branches in Jack Pine as a Function of the Volume Index of the Branch

Figure 55 presents a plot of the number of second versus third order branches, where we have eliminated the third medium jack pine branch from the sample as an outlyer. The linear regression equation which best fits this plot is

$$\text{\# 3rd order branches} = 12.8 + 1.1 \text{ (\# 2nd order) } (R = .85) \qquad (31)$$

Figure 56 presents the relationships between the volume index and the dry weight of the various plant components. The best fit regression equations for these relationships are as follows

Total Branch

$$B_{tb} \text{ (gms)} = 97.4 + .253 \text{ VI } (R = .96) \qquad (32)$$

Branch Only

$$B_{br} \text{ (gms)} = 7.3 + .140 \text{ VI } (R = 0.96) \qquad (33)$$

2nd Order Branches

$$B_{2nd} \text{ (gms)} = 9.8 + .046 \text{ VI } (R = .91) \qquad (34)$$

3rd Order Branches

$$B_{3rd} = 3.2 + .018 \text{ VI } (R = 0.82) \qquad (35)$$

Needles

$$B_n = 13.4 + 19.4 \text{ Log (VI) } (R = .50) \qquad (36)$$

Figure 57 presents the histogram plots and PDF curves for the second and third order branch diameters a... lengths for the sparse and medium jack pine sites. Note that while the average second order branch lengths and diameters were only slightly larger for the medium jack pine site, the third order branch length and diameters were significantly longer. An examination of the relationship between diameter and length for the second and third order branches revealed no significant variation between the two sites.

The number of needles per gram of dry weight weight was 142 for the sparse jack pine sites versus 120 for the medium jack pine site. The average dimensions of the needles were 2.86 by .10 cm for the sparse

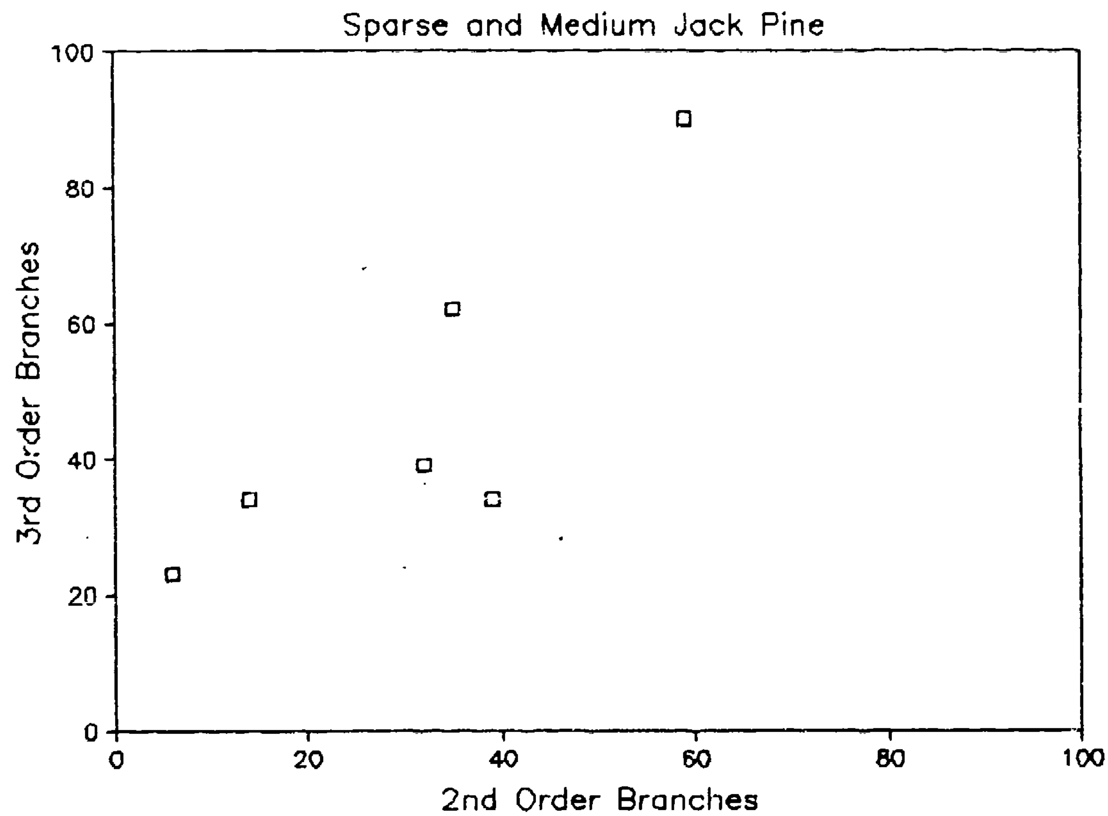
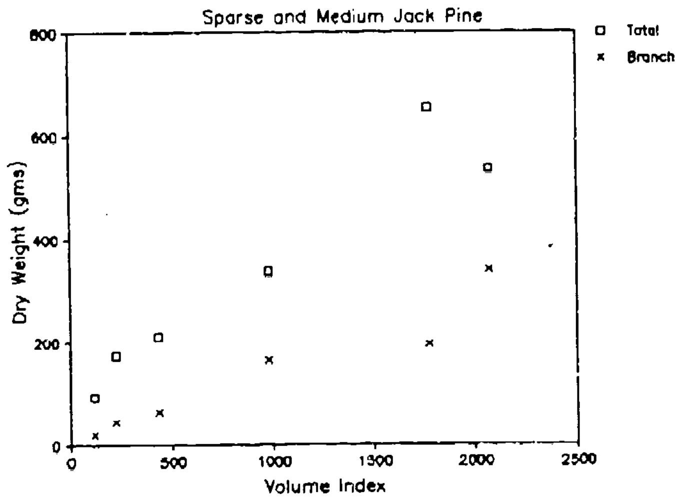


Figure 55. Plot of Number of Third Order Branches as a Function of Number of Second Order Branches

90-10255



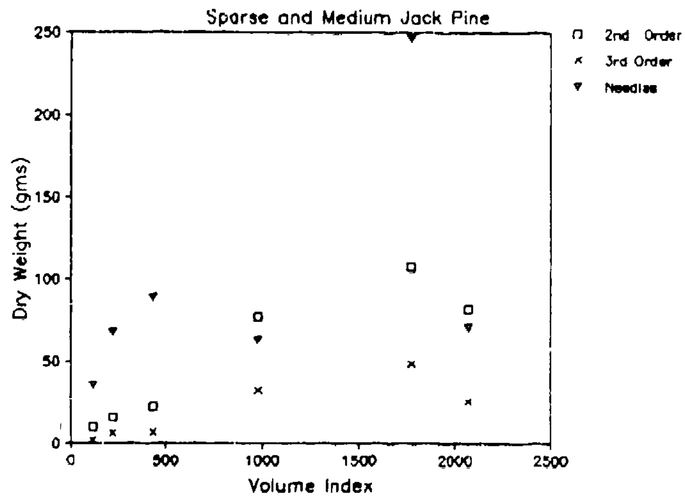


Figure 56. Plot of Volume Index versus Dry Weight Biomass for the Various Components of the Jack Pine Branches

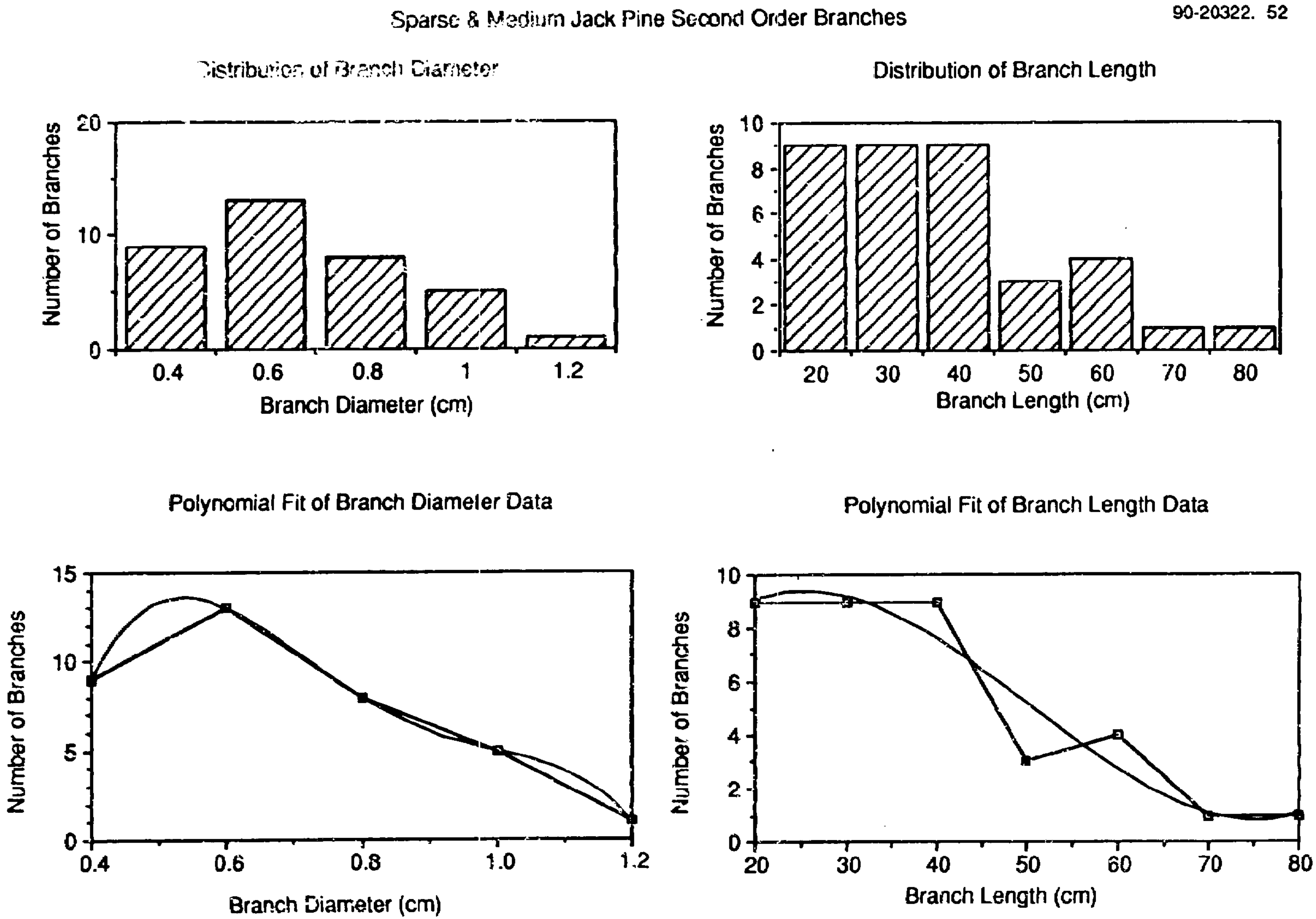


Figure 57. Histogram Plots and PDF Curves for Second and Third Order Branch Diameter and Lengths

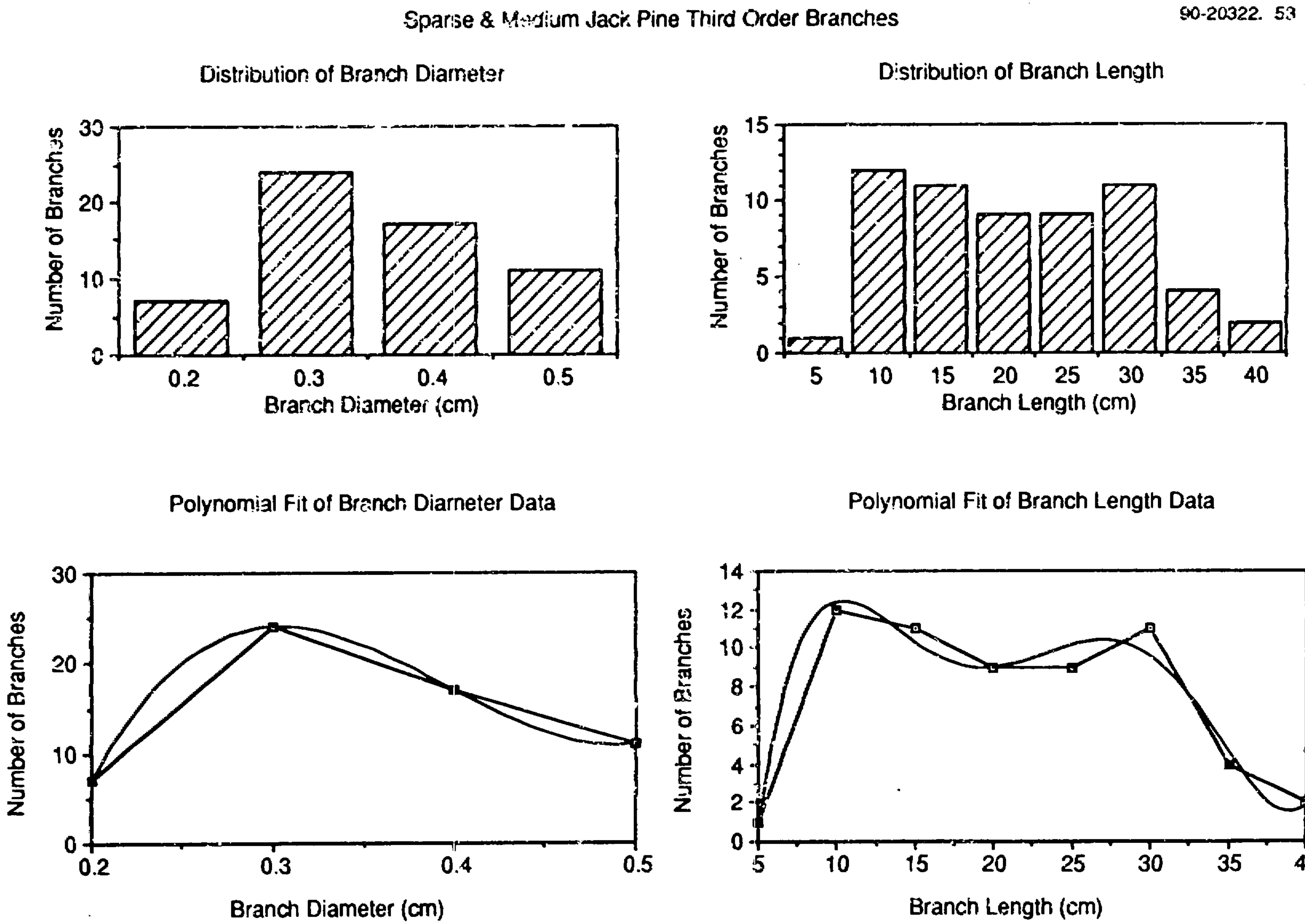


Figure 57 concluded. Histogram Plots and PDF Curves for Second and Third Order Branch Diameter and Lengths.

pine site, and 3.47 by .11 cm for the medium jack pine site, which explains the difference in needle counts.

Branch densities were measured at 0.48 gm/cm^3 for the sparse jack pine sites and 0.58 gm/cm^3 for the medium jack pine site. Measurements by MacLean and Wein (1976) show that jack pine branches are typically 50% moisture by weight, whereas the needles are 47% moisture by weight.

Figures 58 through 64 present the histogram plots and PDF curves for the tree diameters and heights for the sparse jack pine sites. The polynomial equations for the PDFs are summarized in Table 17.

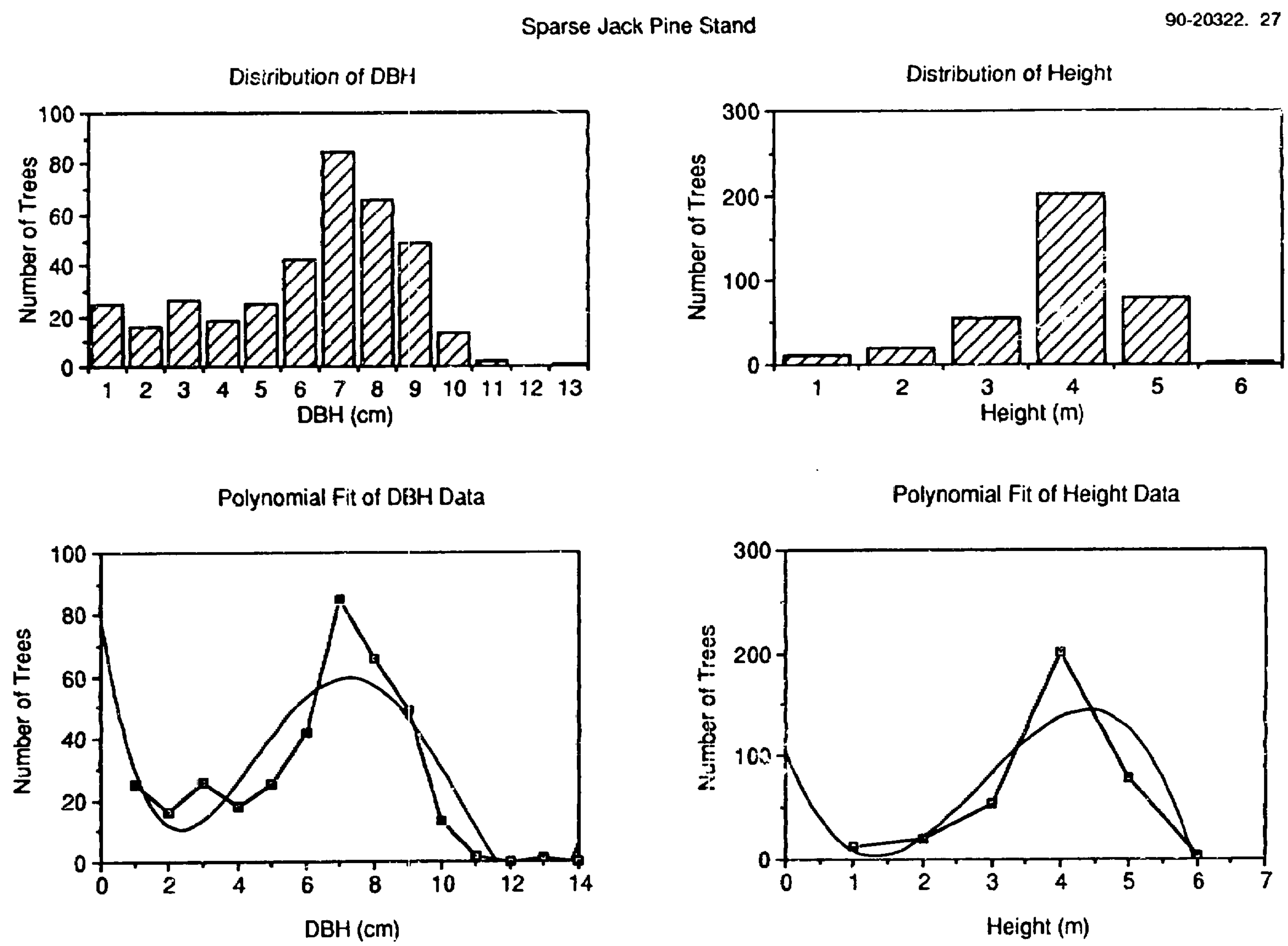


Figure 58. Histogram Plots of Diameters and Heights and PDF Curves for All Sparse Jack Pine Sites Combined

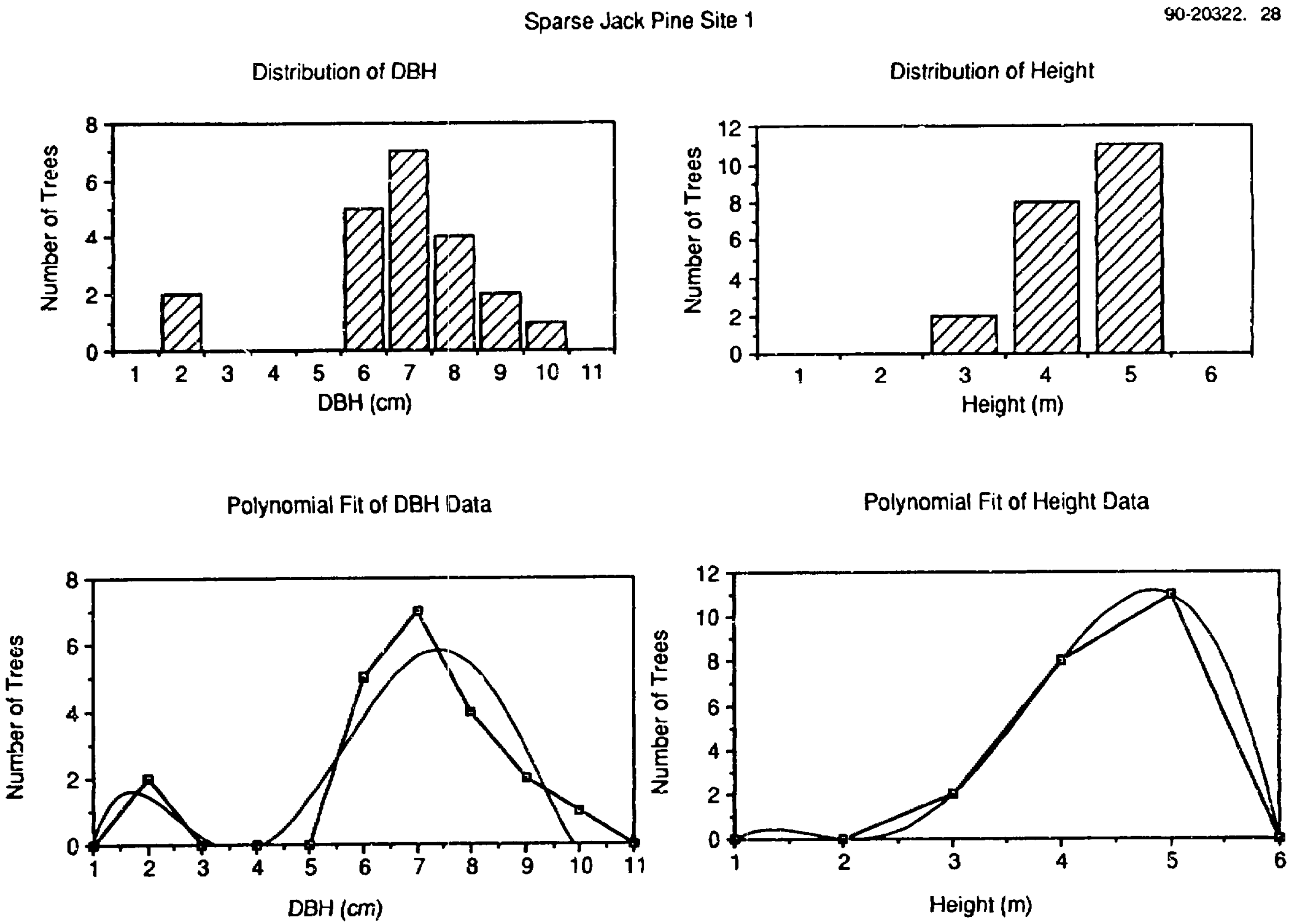


Figure 59. Histogram Plots of Diameters and Heights and PDF Curves for Sparse Jack Pine Site 1

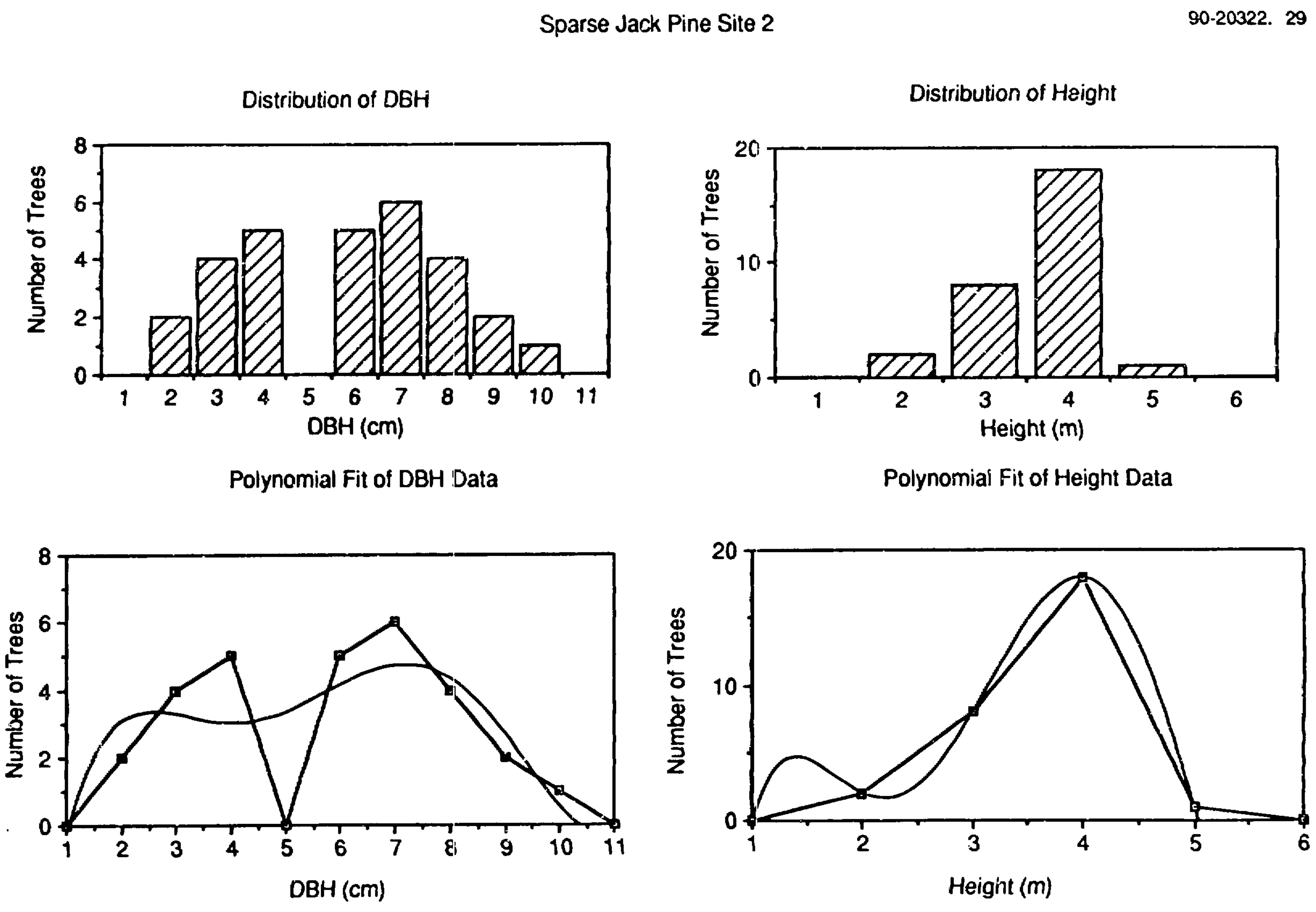


Figure 60. Histogram Plots of Diameters and Heights and PDF Curves for Sparse Jack Pine Site 2

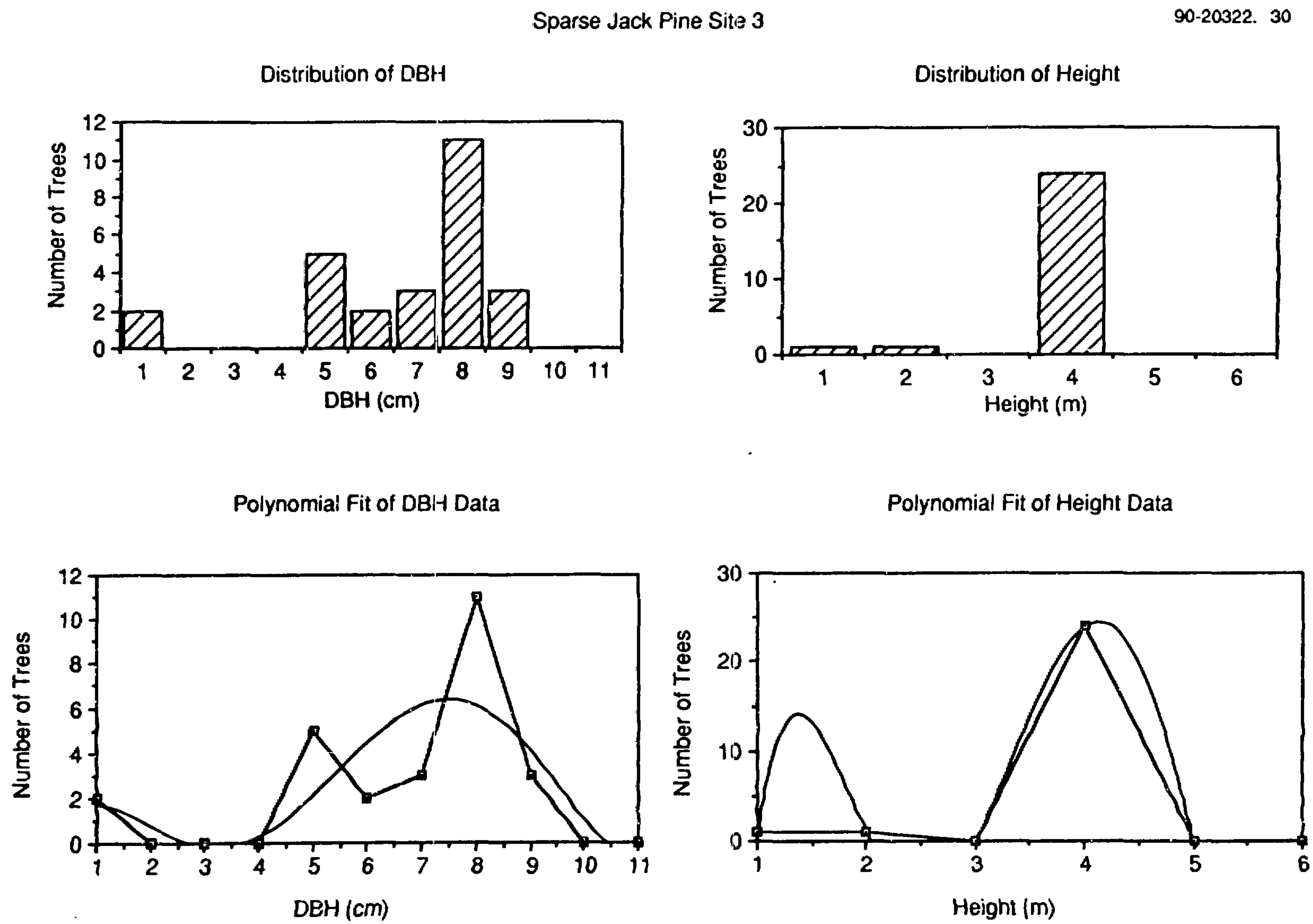


Figure 61. Histogram Plots of Diameters and Heights and PDF Curves for Sparse Jack Pine Site 3

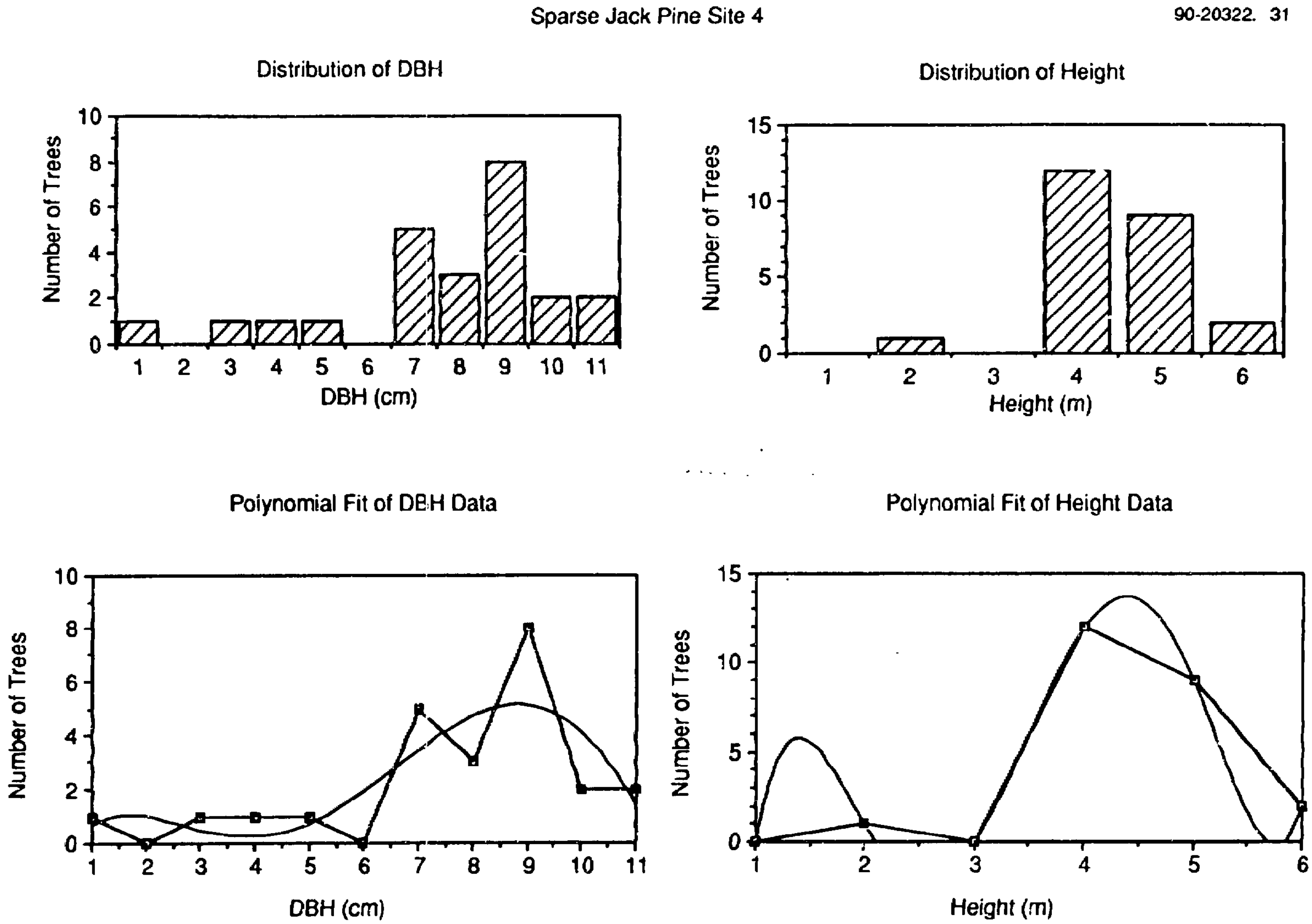


Figure 62. Histogram Plots of Diameters and Heights and PDF Curves for Sparse Jack Pine Site 4

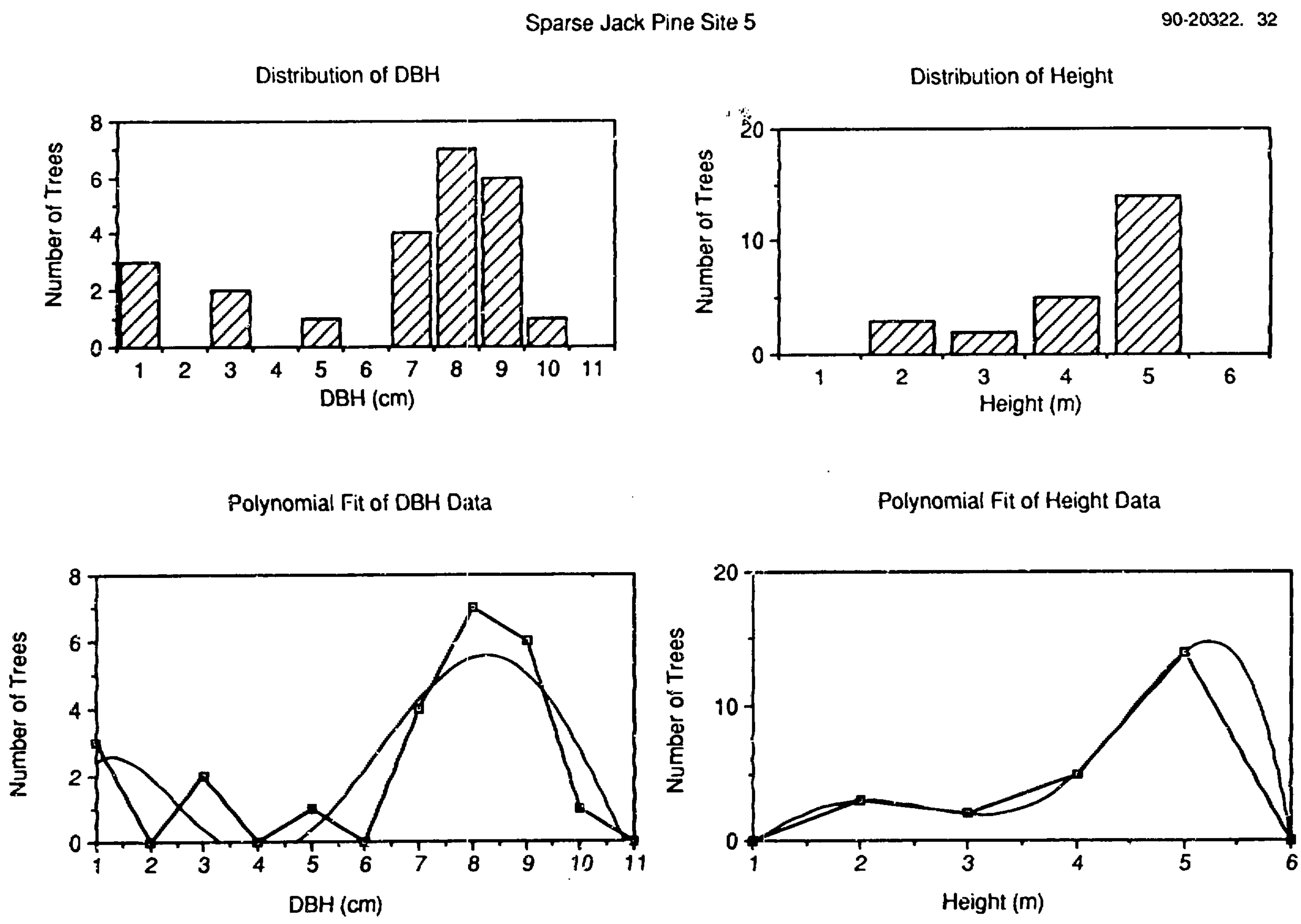


Figure 63. Histogram Plots of Diameters and Heights and PDF Curves for Sparse Jack Pine Site 5

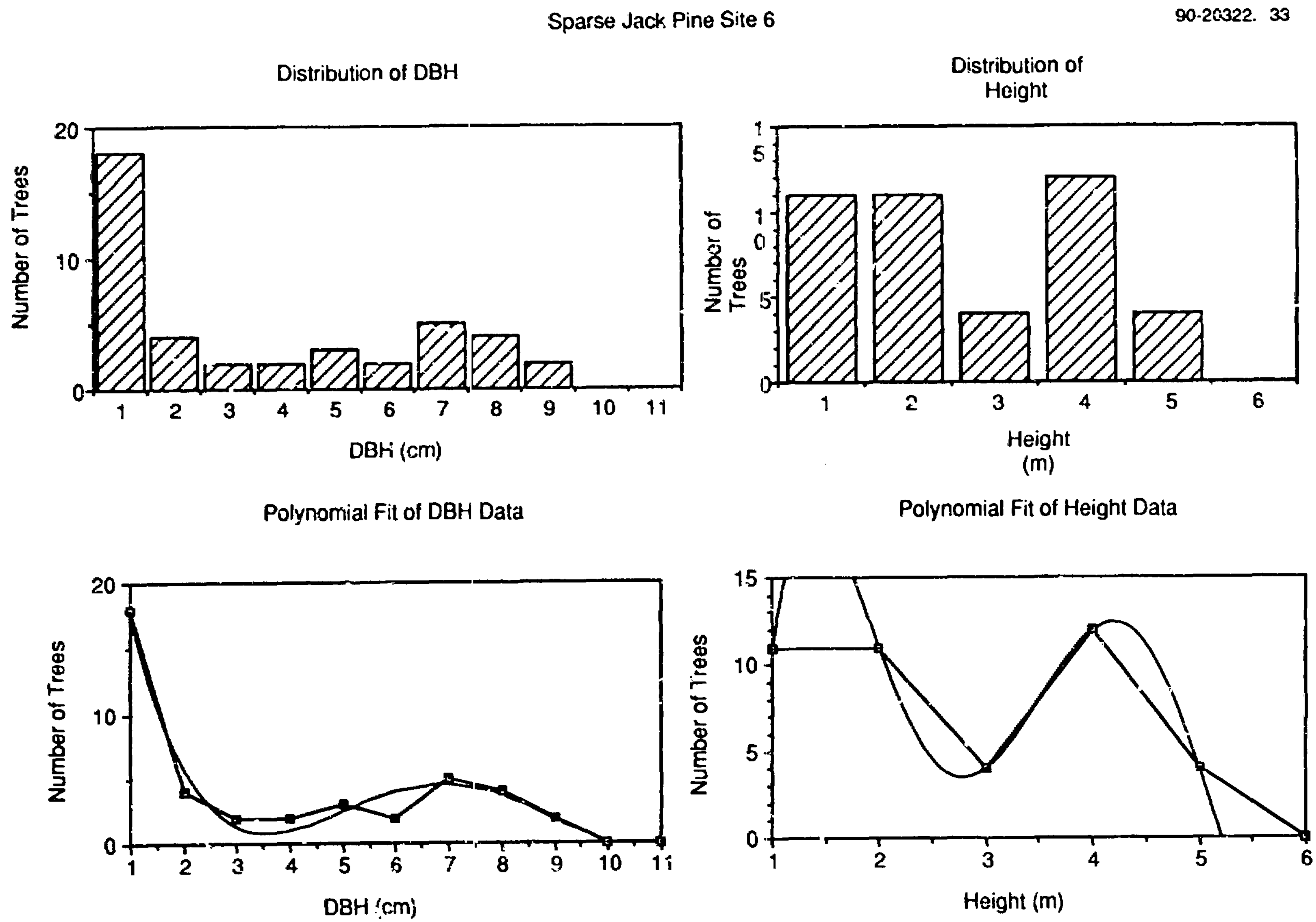


Figure 64. Histogram Plots of Diameters and Heights and PDF Curves for Sparse Jack Pine Site 6

TABLE 17
SUMMARY OF POLYNOMIAL EQUATIONS FOR DIAMETER AND HEIGHT PDFS FOR THE SPARSE JACK PINE STAND

Entire Stand:

Diameter: x = tree diameter in cm

$Y = 78.648-69.213x+22.207x^2-2.3719x^3+7.9447e^{-2}x^4$
R^2 0.781

Height: tree height in m

$Y = 105.00-170.64x+83.750x^2-9.7500x^3$
$R^2 = 0.736$

Reflector Site 1:

Diameter: x = tree diameter in cm

$Y = -10.576+18.913x-10.239x^2+2.3135x^3-0.22378x^4+7.6923e^{-3}x^5$
$R^2 = 0.825$

Height: x = tree height in m

$Y = -14.000+30.833x-23.500x^2+7.6250x^3-1.0000x^4+4.1667e^{-2}x^5$
$R^2 = 1.000$

Reflector Site 2

Diameter: x = tree diameter in cm

$Y = -11.788+17.860x-7.7672x^2+1.5341x^3-0.13724x^4+4.4872e^{-3}x^5$
$R^2 = 0.604$

Height: x = tree height in m

$Y = -134.00+300.33x-240.08x^2+87.292x^3-14.417x^4+0.87500x^5$
$R^2 = 1.000$

Reflector Site 3:

Diameter: x = tree diameter in cm

$Y = -0.51515+5.4832x-4.3026x^2+1.1637x^3-0.12194x^4+4.3269e^{-3}x^5$
$R^2 = 0.536$

Height: x = tree height in m

$Y = -369.00+812.55x-628.38x^2+218.42x^3-34.625x^4+2.0333x^5$
$R^2 = 1.000$

TABLE 17 (concluded)

SUMMARY OF POLYNOMIAL EQUATIONS FOR DIAMETER AND HEIGHT PDFS FOR THE SPARSE JACK PINE STAND

Reflector Site 4:

Diameter: x = tree diameter in cm

$$Y = -2.4545+5.4002x-2.7995x^2+0.57051x^3-4.6520e^{-2}x^4+1.2821e^{-3}x^5$$
$$R^2 = 0.580$$

Height: x = tree height in m

$$Y = -143.00+308.32x-232.46x^2+78.500x^3-12.042x^4+0.68333x^5$$
$$R^2 = 1.000$$

Reflector Site 5:

Diameter: x = tree diameter in cm

$$Y = -2.0606+8.7177x-5.3291x^2+1.1906x^3-0.10766x^4+3.3654e^{-3}x^5$$
$$R^2 = 0.704$$

Height: x = tree height in m

$$Y = 4.0000-20.917x+28.125x^2-13.875x^3+2.8750x^4-0.20833x^5$$
$$R^2 = 1.000$$

Reflector Site 6:

Diameter: x = tree diameter in cm

$$Y = 40.061-29.617x+7.7057x^2-0.79992x^3+2.8555e^{-2}x^4$$
$$R^2 = 0.962$$

Height: x = tree height in m

$$Y = -175.00+398.72x-297.79x^2+99.417x^3-15.208x^4+0.86667x^5$$
$$R^2 = 1.000$$

3.2.1.2 Medium Jack Pine Data

The tree measurements for the medium jack pine trees are summarized in Table 18. In Figure 65, we present a plot of tree diameter versus total tree height and height to lowest living branch. From this plot, we can again see that the height to the lowest living branch is again constant (1.1 m). The relationship between diameter and total height can be expressed as

$$\text{Ht (m)} = 1.78 + .398 \text{ dia (cm)} \quad (R = .90) \tag{37}$$

Finally, Figures 66 through 72 present the histogram plots and PDF curves for the tree diameters and heights for the dense jack pine sites. The polynomial equations for the PDFs are summarized in Table 19.

TABLE 18

SUMMARY OF MEDIUM JACK PINE STAND MEASUREMENTS

Site	Total Trees	Trees per Hectare	Diameter Average	Diameter Std Dev	Height Average	Height Std dev
1	38	1137	10.4	2.39	5.9	.84
2	46	1376	9.7	2.34	5.7	.82
3	36	1077	9.8	2.80	5.7	.99
4	30	897	9.2	3.33	5.5	1.17
5	39	1167	9.5	6.91	5.6	2.43
6	36	1077	5.7	4.25	4.3	1.52
Total		1122	9.1	4.28	5.5	1.51

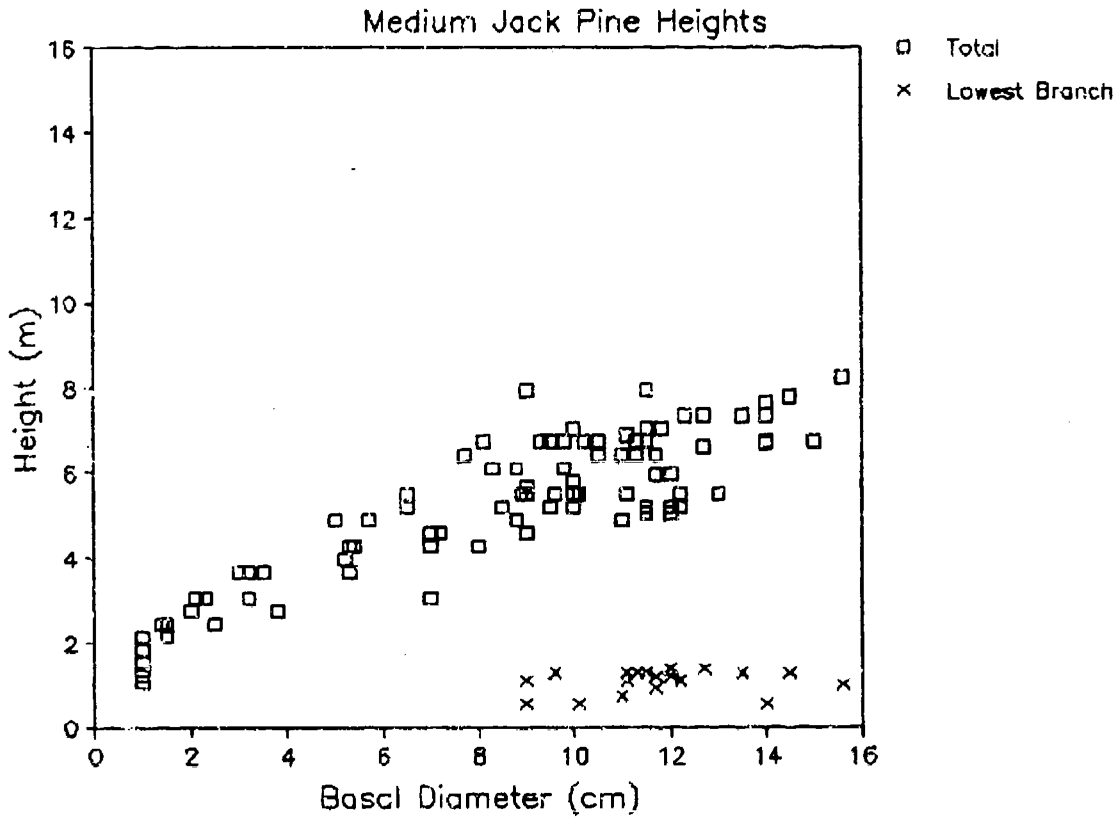


Figure 65. Relationship Between Tree Diameter and Total Height and Height to Lowest Living Branch for Medium Jack Pine Stand

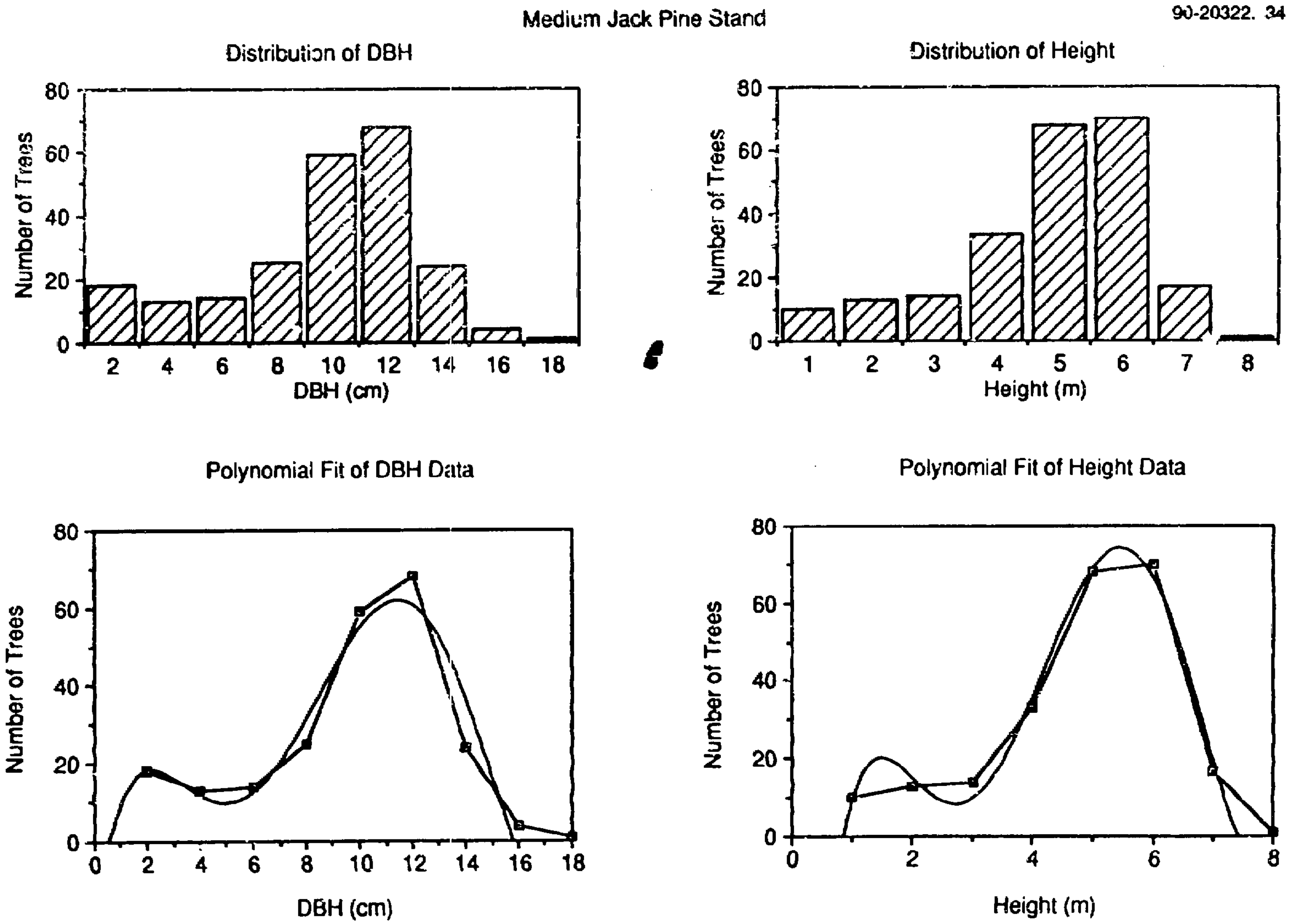


Figure 66. Histogram Plots of Diameters and Heights and PDF Curves for All Medium Jack Pine Sites Combined

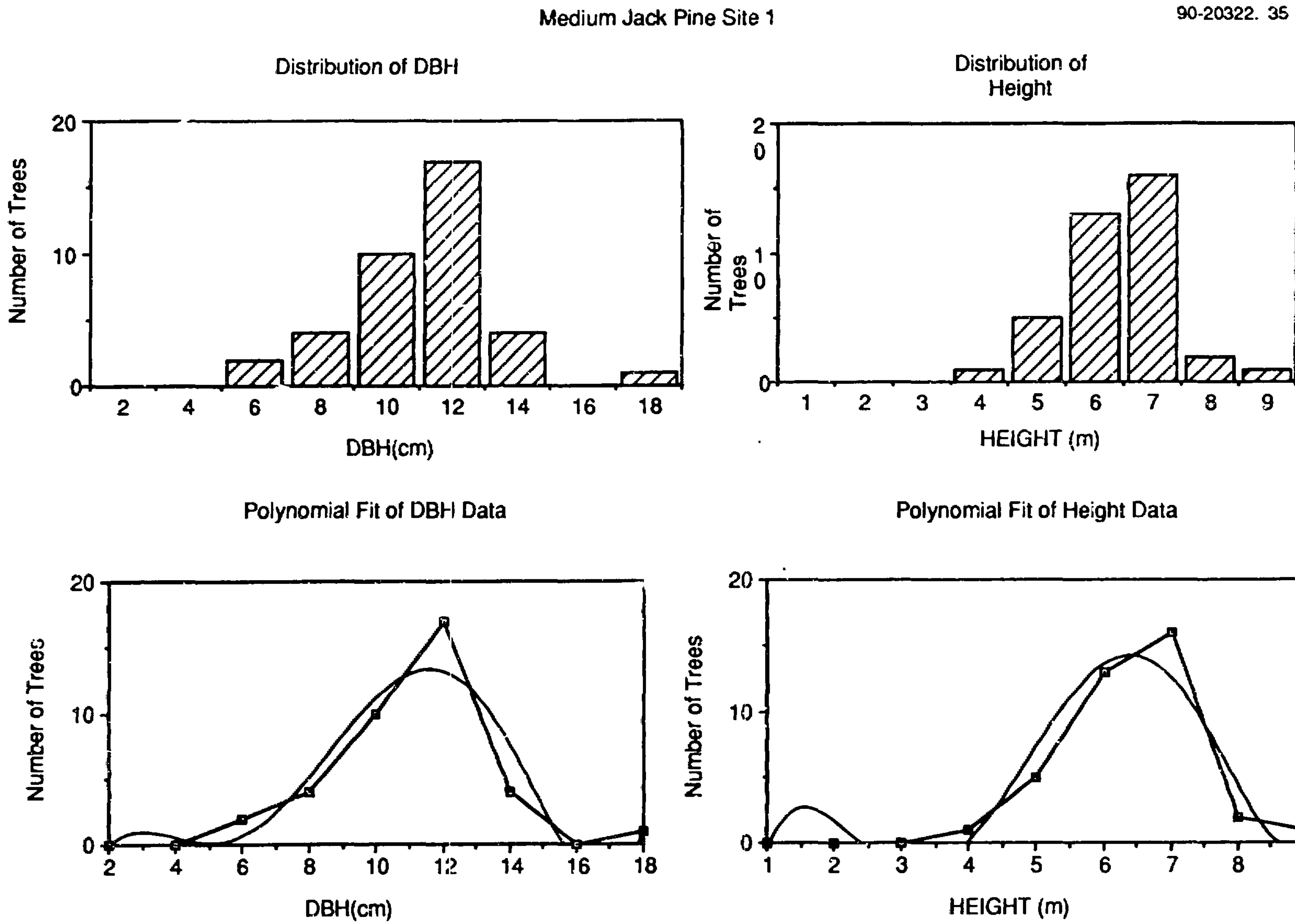


Figure 67. Histogram Plots of Diameters and Heights and PDF Curves for Medium Jack Pine Site 1

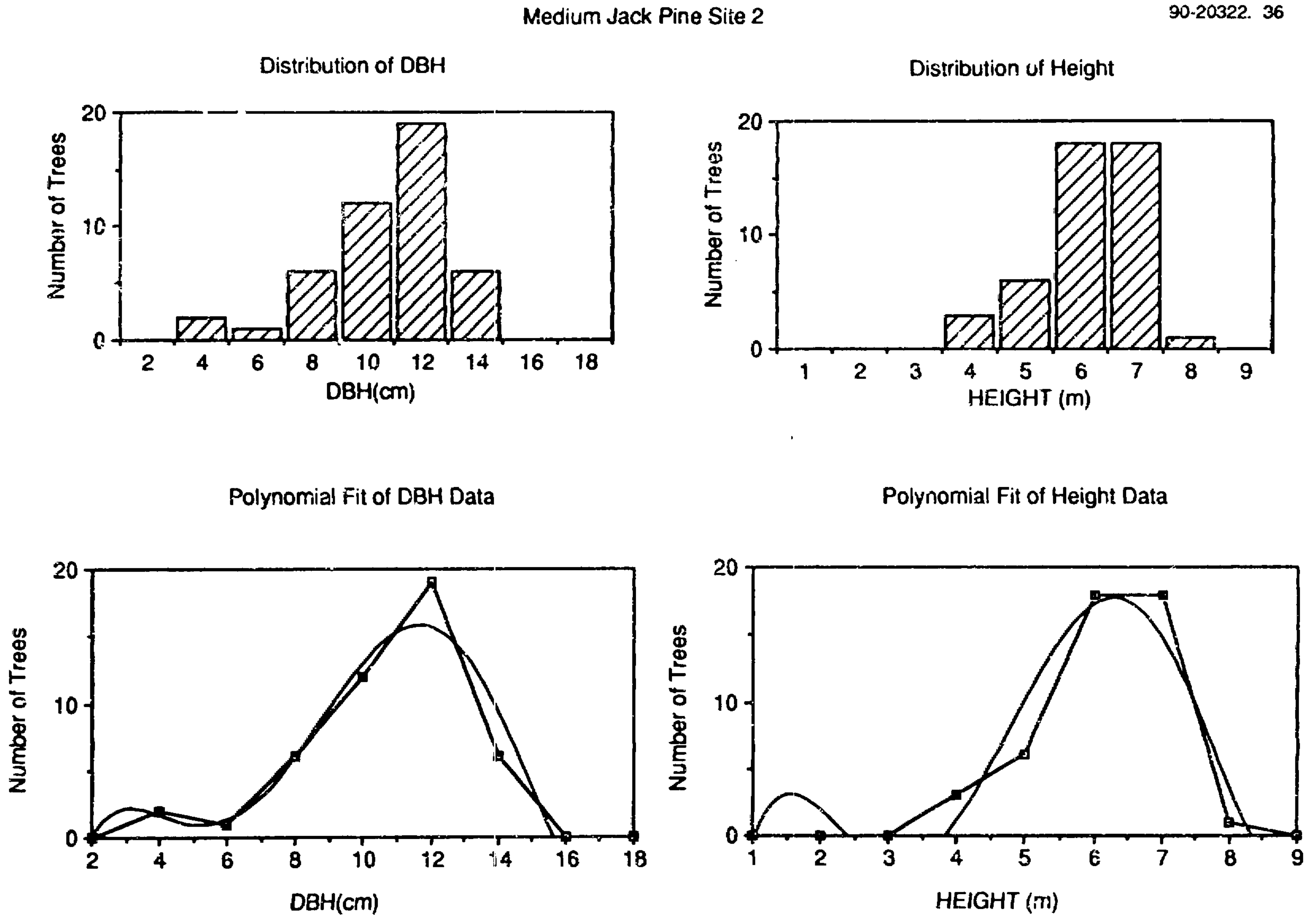


Figure 68. Histogram Plots of Diameters and Heights and PDF Curves for Medium Jack Pine Site 2

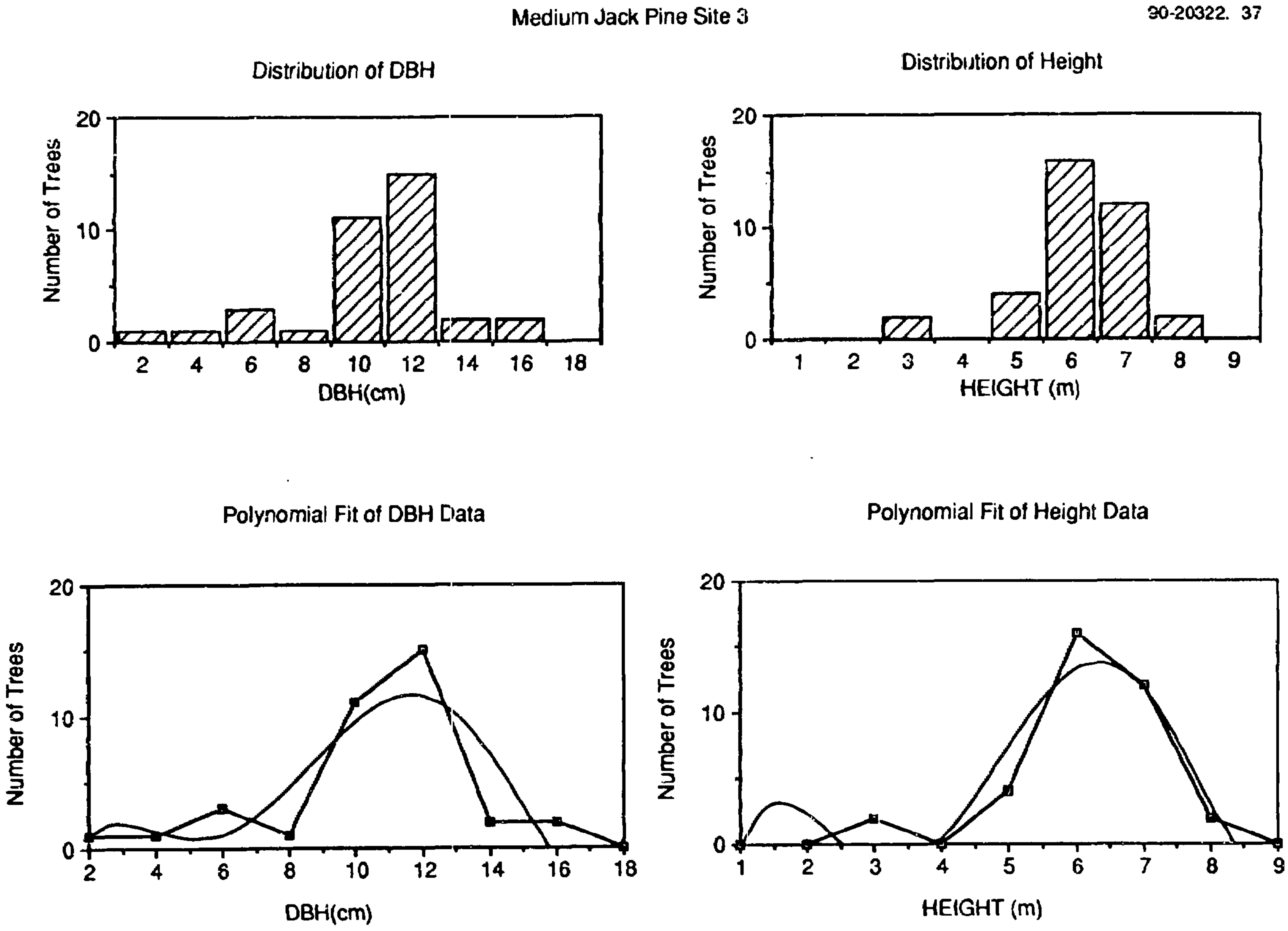


Figure 69. Histogram Plots of Diameters and Heights and PDF Curves for Medium Jack Pine Site 3

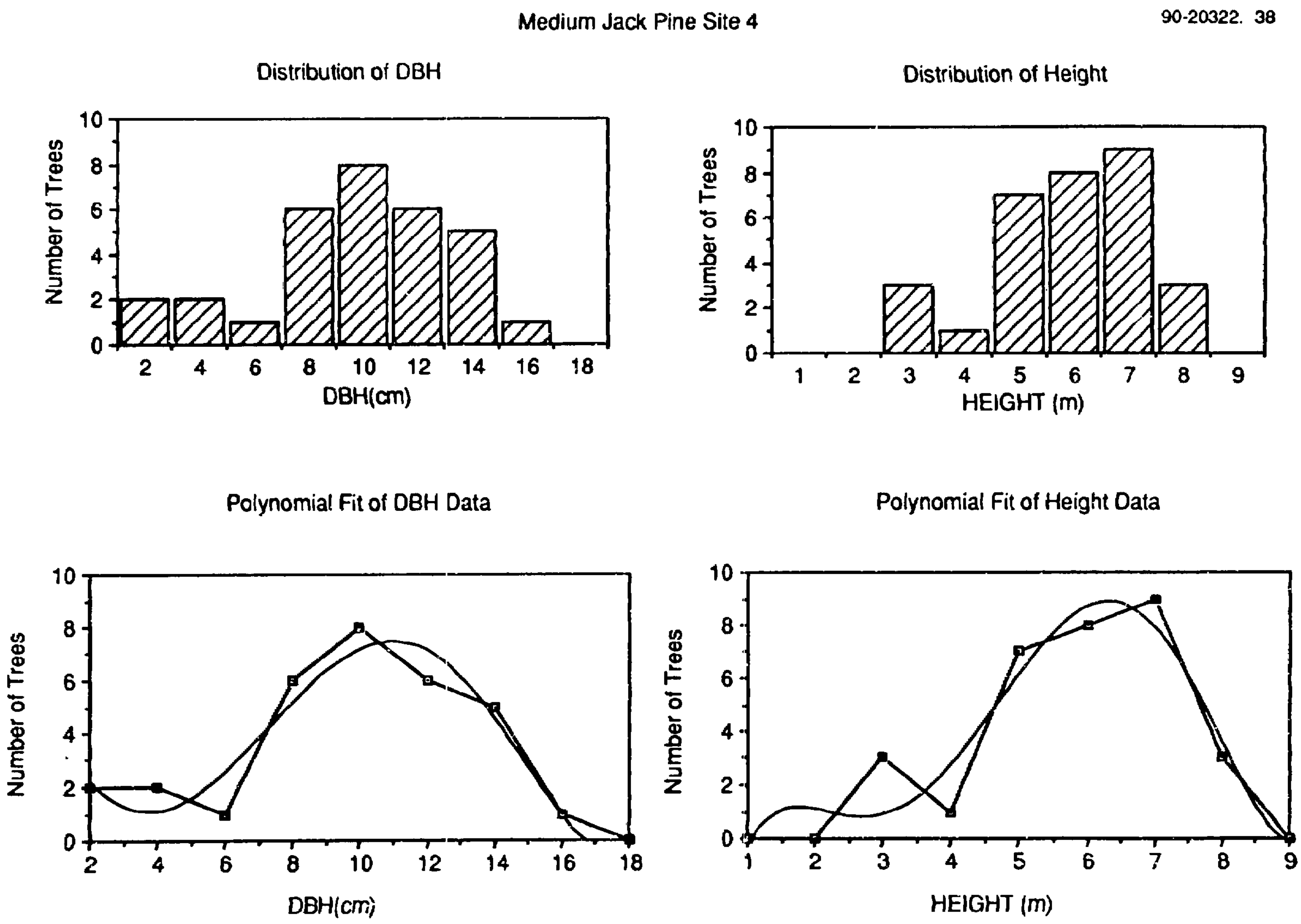


Figure 70. Histogram Plots of Diameters and Heights and PDF Curves for Medium Jack Pine Site 4

90-20322. 39

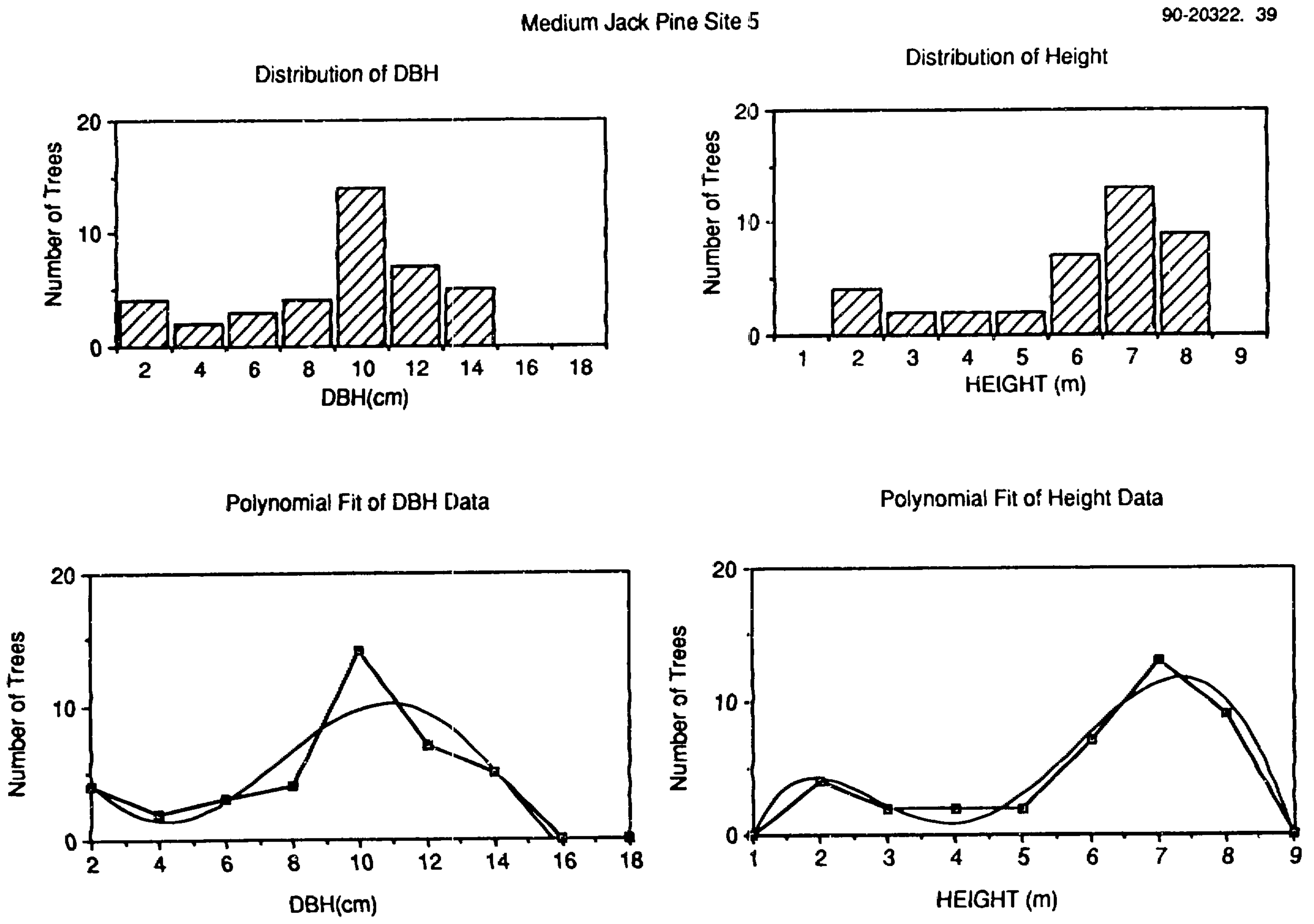


Figure 71. Histogram Plots of Diameters and Heights and PDF Curves for Medium Jack Pine Site 5

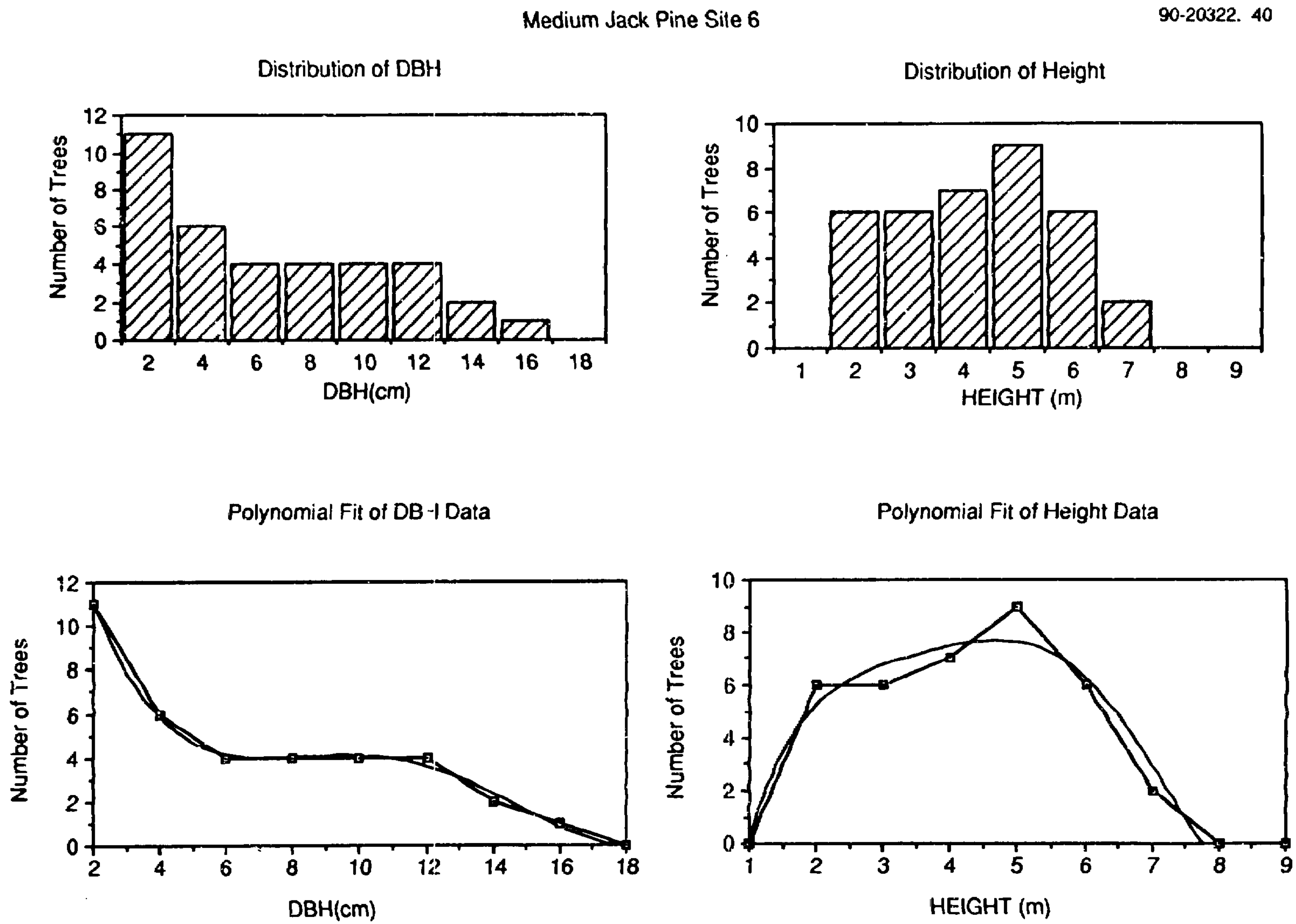


Figure 72. Histogram Plots of Diameters and Heights and PDF Curves for Medium Jack Pine Site 6

TABLE 19

SUMMARY OF POLYNOMIAL EQUATIONS FOR DIAMETER AND HEIGHT PDFS FOR THE MEDIUM JACK PINE STAND

Entire Stand:

Diameter: x = tree diameter in cm

$$Y = -22.333+48.457x-19.502x^2+3.1248x^3-0.20405x^4+4.5873e^{-3}x^5$$
$$R^2 = 0.926$$

Height: x = tree height in m

$$Y = 170.25+361.04x-244.23^2+71.766x^3-9.2079x^4+0.42372x^5$$
$$R^2 = 0.990$$

Reflector Site 1:

Diameter: x = tree diameter in cm

$$Y = -18.583+18.739x-6.3981x^2+0.94134x^3-5.8830e^{-2}x^4+1.2921e^{-3}x^5$$
$$R^2 = 0.866$$

Height: x = tree height in m

$$Y = 37.333+69.583x-42.482x^2+10.989x^3-1.2305x^4+4.9359e^{-2}x^5$$
$$R^2 = 0.897$$

Reflector Site 2:

Diameter: x = tree diameter in cm

$$Y = -26.583+26.122x-8.5252x^2+1.2094x^3-7.3763e^{-2}x^4+1.5925e^{-3}x^5$$
$$R^2 = 0.921$$

Height: x = tree height in m

$$Y = 45.000+84.376x-52.037x^2+13.643x^3-1.5478x^4+6.2821e^{-2}x5$$
$$R^2 = 0.899$$

Reflector Site 3:

Diameter: x = tree diameter in cm

$$Y = -14.750+16.015x-5.4656x^2+0.79613x^3-4.9252e^{-2}x^4+1.0717e^{-3}x^5$$
$$R^2 = 0.708$$

Height: x = tree height in m

$$Y = -40.500+74.635x-44.966x^2+11.554x^3-1.2922x^4+5.1923e^{-2}x^5$$
$$R^2 = 0.866$$

TABLE 19 (concluded)

SUMMARY OF POLYNOMIAL EQUATIONS FOR DIAMETER AND HEIGHT PDFS FOR THE MEDIUM JACK PINE STAND

Reflector Site 4:

Diameter: x = tree diameter in cm

$$Y = 6.0833-2.4760x+0.17537x^2+5.6982e^{-2}x^3-6.7654e^{-3}x^4+1.9030e^{-4}x^5$$
$$R^2 = 0.906$$

Height: x = tree height in m

$$Y = -12.833+23.438x-14.184x^2+3.7643x^3-0.42920x^4+1.7308e^{-2}x^5$$
$$R^2 = 0.892$$

Reflector Site 5:

Diameter: x = tree diameter in cm

$$Y = 10.083-3.0823x-0.20815x^2+0.16512x^3-1.5488e^{-2}x^4+4.1066e^{-4}x^5$$
$$R^2 = 0.781$$

Height: x = tree height in m

$$Y = -24.500+40760x-20.179x^2+4.1833x^3-0.36597x^4+1.0897e^{-2}x^5$$
$$R^2 = 0.958$$

Reflector Site 6:

Diameter: x tree diameter in cm

$$Y = 22.333-7.6593x+1.1458x^2-7.1703e^{-2}x^3+1.5479e^{-3}x^4$$
$$R^2 = 0.995$$

Height: tree height in m

$$Y = 15.750+25.101x-11.603^{x2}+2.7230x^3-0.30959x^4+1.3141e^{-2}x^5$$
$$R^2 = 0.950$$

3.2.1.3 Dense Jack Pine Data

Table 20 summarizes the dense jack pine stand measurements. In Figure 73, the relationship between tree diameter and total height and height to lowest living branch is presented, while in Figure 74 we present the relationship between tree diameter and canopy depth. From these data, with the elimination of outlyer points the following relationships can be established:

$$Ht\ (m) = 11.80 + .34\ dia\ (cm) \quad (R = .68) \tag{38}$$

$$C_d\ (m) = 1.38 + .29\ dia\ (cm) \quad (R = .57) \tag{39}$$

Figure 75 presents plots of relative tree positions for the various dense jack pine sites. Because of the sampling method used for site 3, no plots are presented for it. Figures 76 through 81 present the histogram plots and PDF curves for the tree diameters and heights for the dense jack pine sites. The polynomial equations for the PDFs are summarized in Table 21.

Finally, in Figure 82 we present a histogram plot and PDF curves for the branching angles (in degrees relative to the trunk of the tree) of mature jack pine trees. These data were provided by Dr. Paul Hanover and Paul Bloese of Michigan State University.

3.2.2 Allometric Equations

In this section, we will discuss the various allometric equations for jack pine which are available in the literature. Green and Grigal (1978) developed two groups of biomass estimation equations for several components of jack pine including total mass, total live mass, live branch mass, dead branch mass, and needle mass. The first group uses diameter and height as independent variables and the second uses diameter alone. Data were collected by four different investigators in

TABLE 20

SUMMARY OF DENSE JACK PINE STAND MEASUREMENTS

	Total Trees	Trees per Hectare	Diameter Average (cm)	Diameter Std Dev	Height Average (m)	Height Std Dev
Living Pines						
Site 1	104	662	20.0	7.00	18.5	1.70
Site 2	91	508	22.4	15.83	19.1	3.85
Site 3	141	652	19.1	4.76	18.3	1.52
Site 4	153	707	17.3	5.49	17.3	1.33
Site 5	86	397	20.5	6.46	18.6	1.54
Total		585	19.5	8.45	18.4	2.04
Total Trees						
Site 1	132	840	18.9	7.18		
Site 2	150	837	20.0	13.91		
Site 3	215	994	17.5	5.49		
Site 4	214	989	16.6	5.56		
Site 5	101	456	20.6	7.84		
Total		823	18.3	8.29		

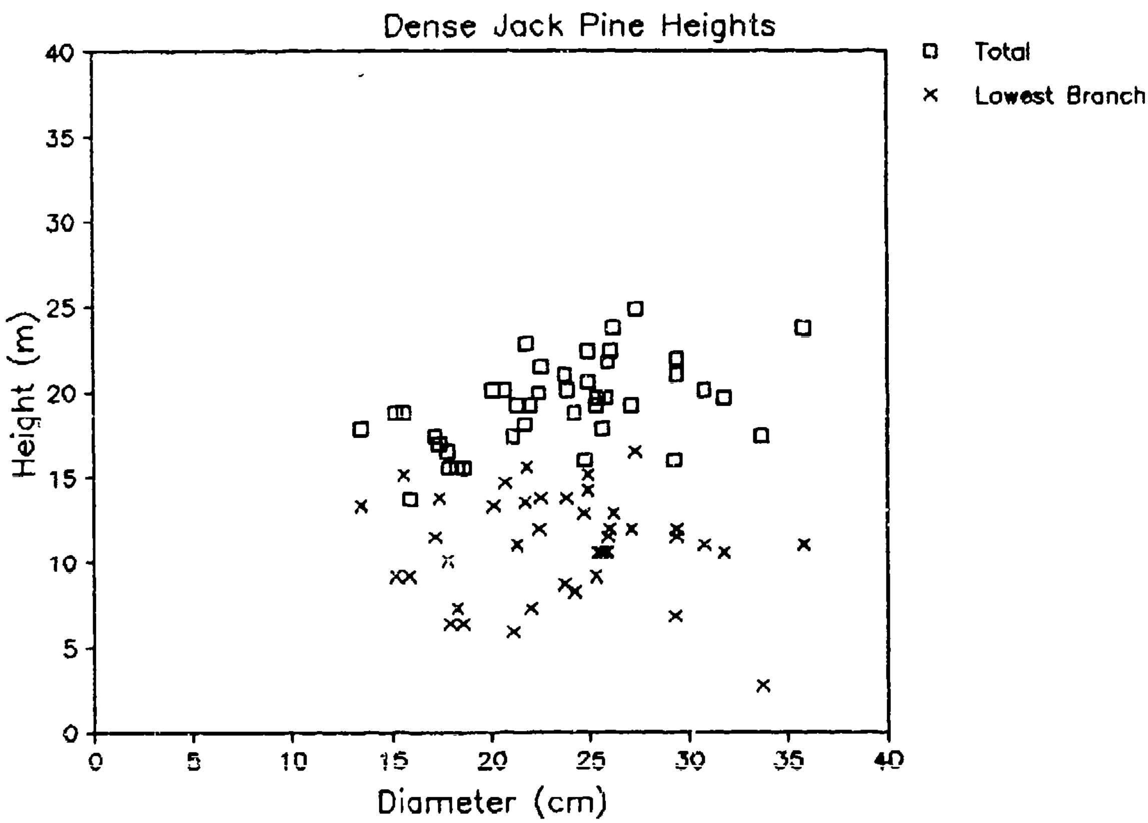


Figure 73. Relationship Between Tree Diameter and Total Height and Height to Lowest Living Branch for the Dense Jack Pine Stand

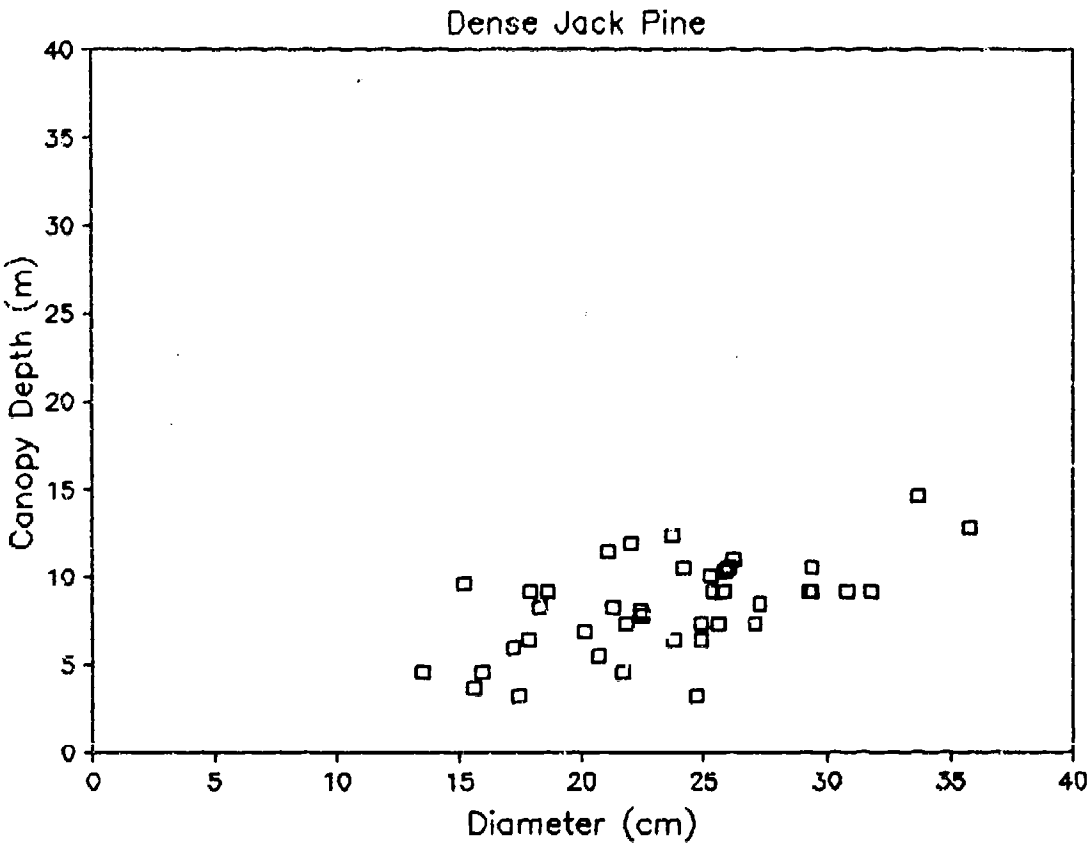


Figure 74. Relationship Between Tree Diameter and Canopy Depth for the Dense Jack Pine Stand

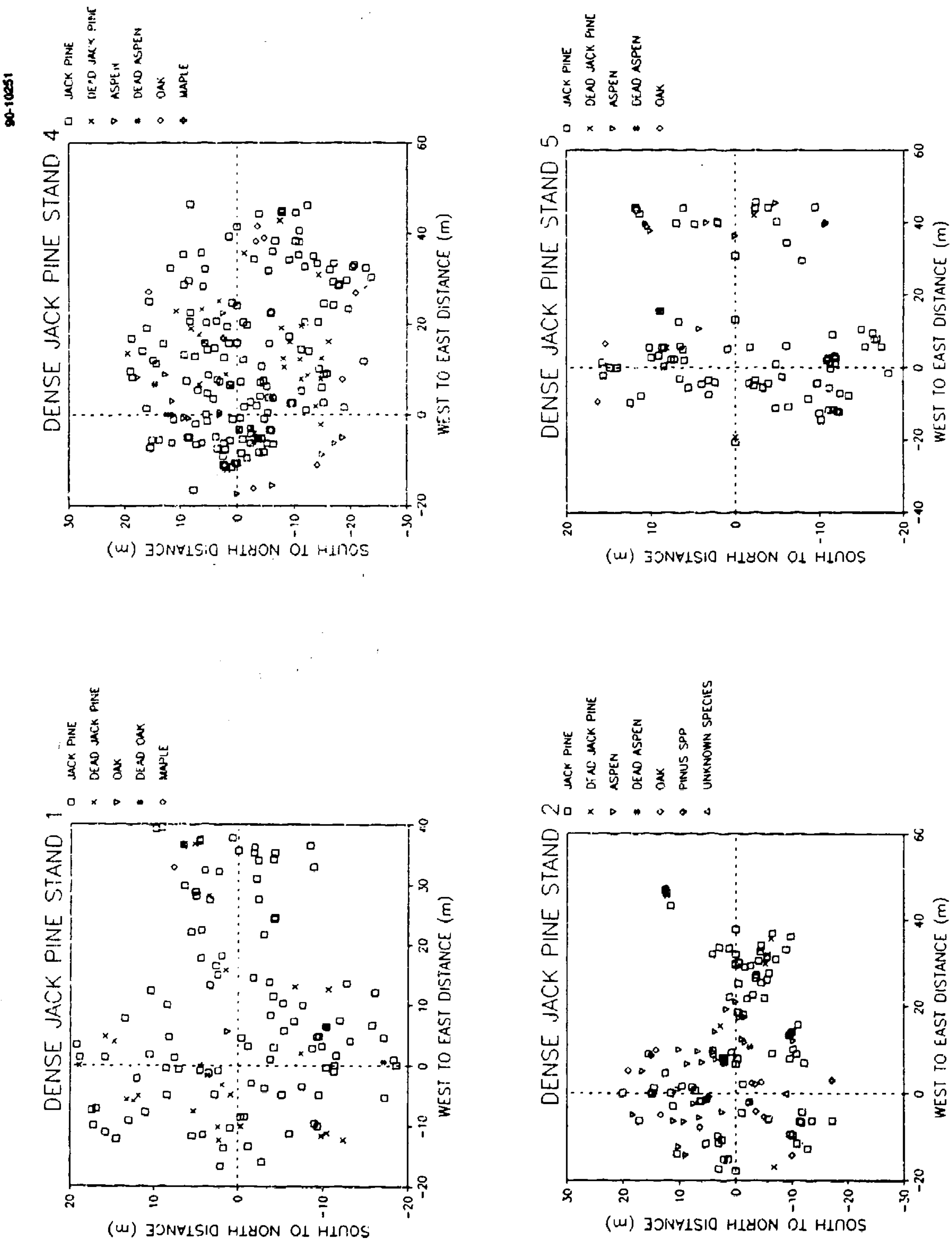


Figure 75. Relative Positions of Trees to Corner Reflector for the Dense Jack Pine Sites

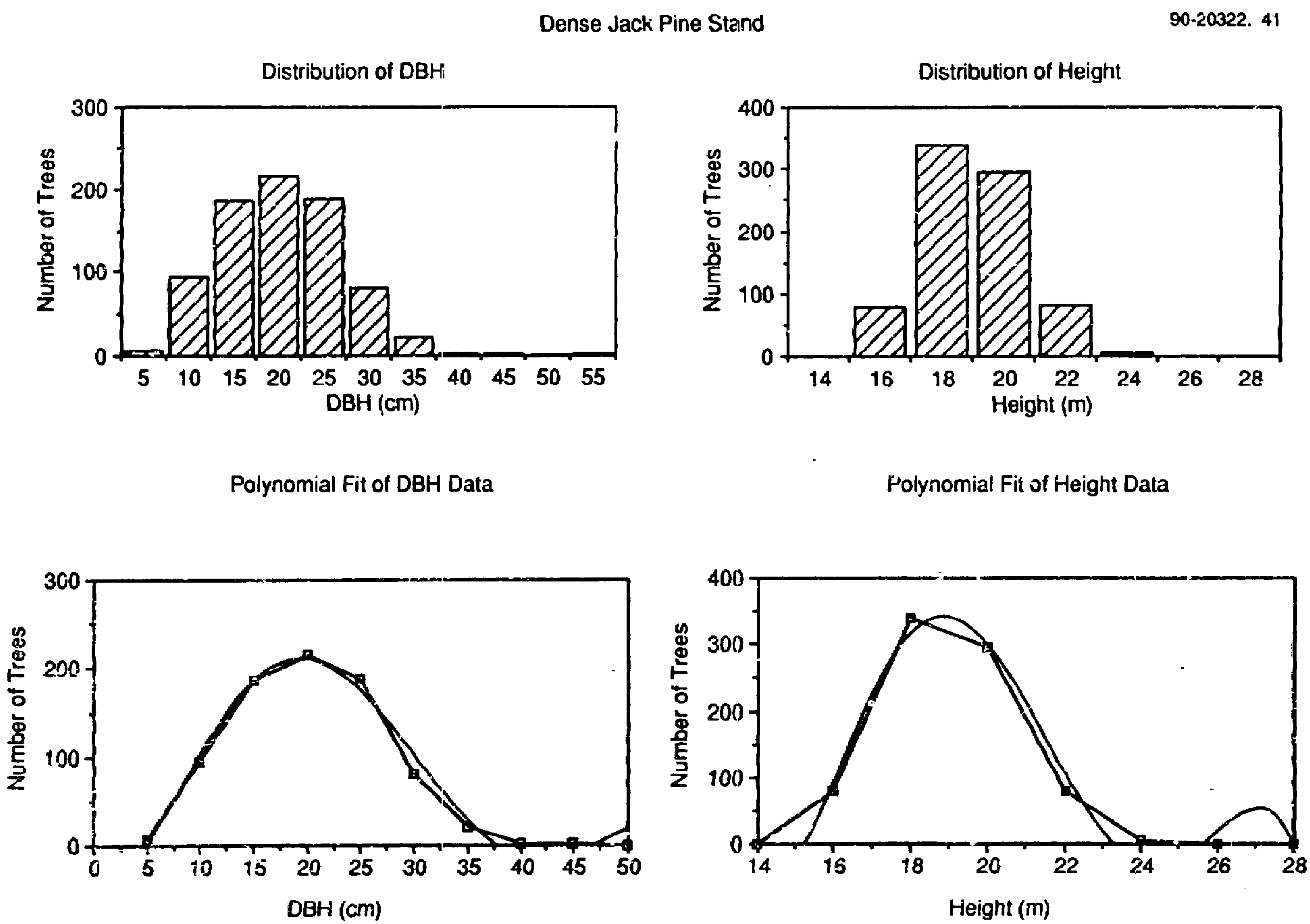


Figure 76. Histogram Plots of Diameters and Heights and PDF Curves for All Dense Jack Pine Sites Combined

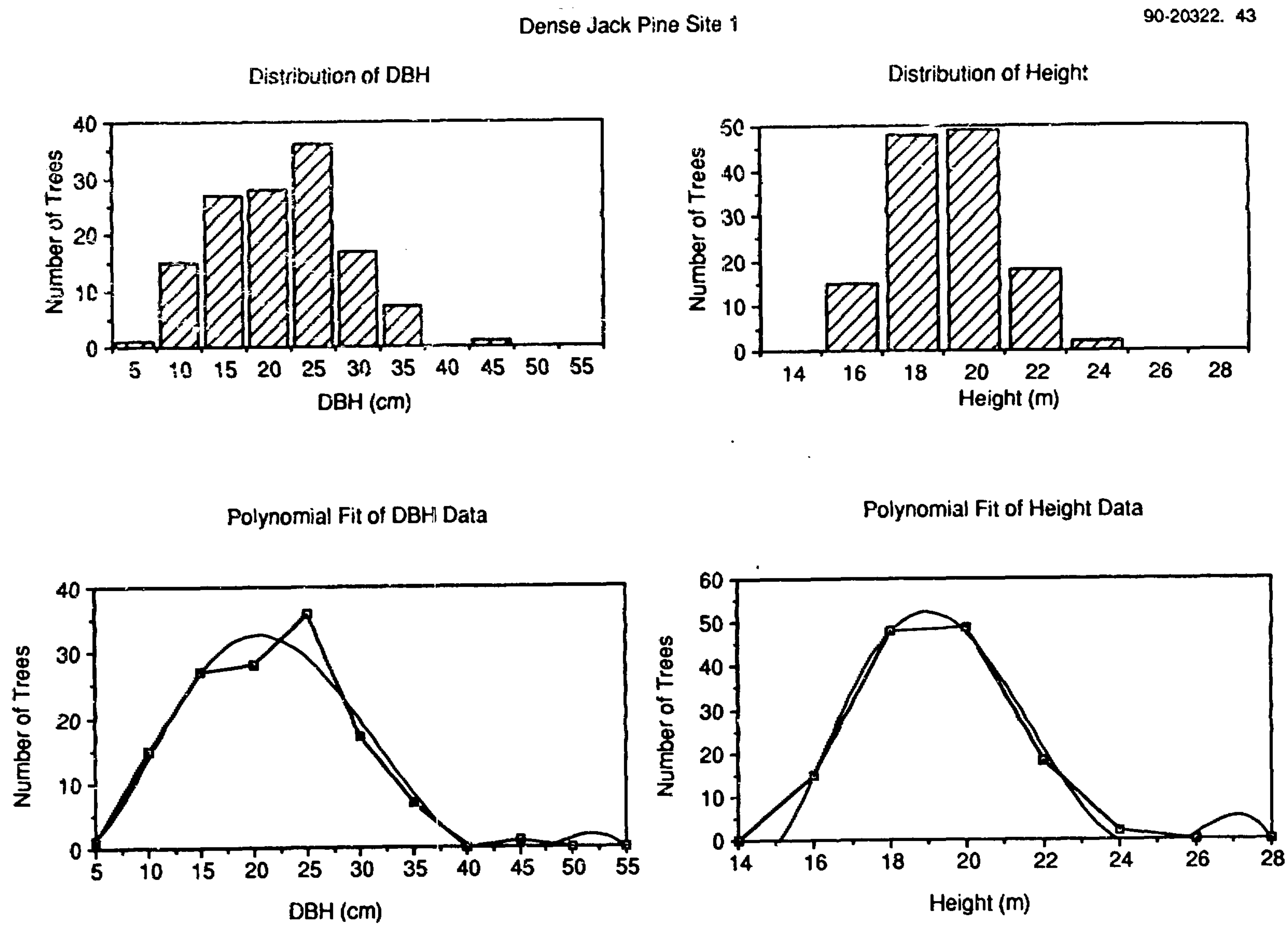


Figure 77. Histogram Plots of Diameters and Heights and PDF Curves for Dense Jack Pine Site 1

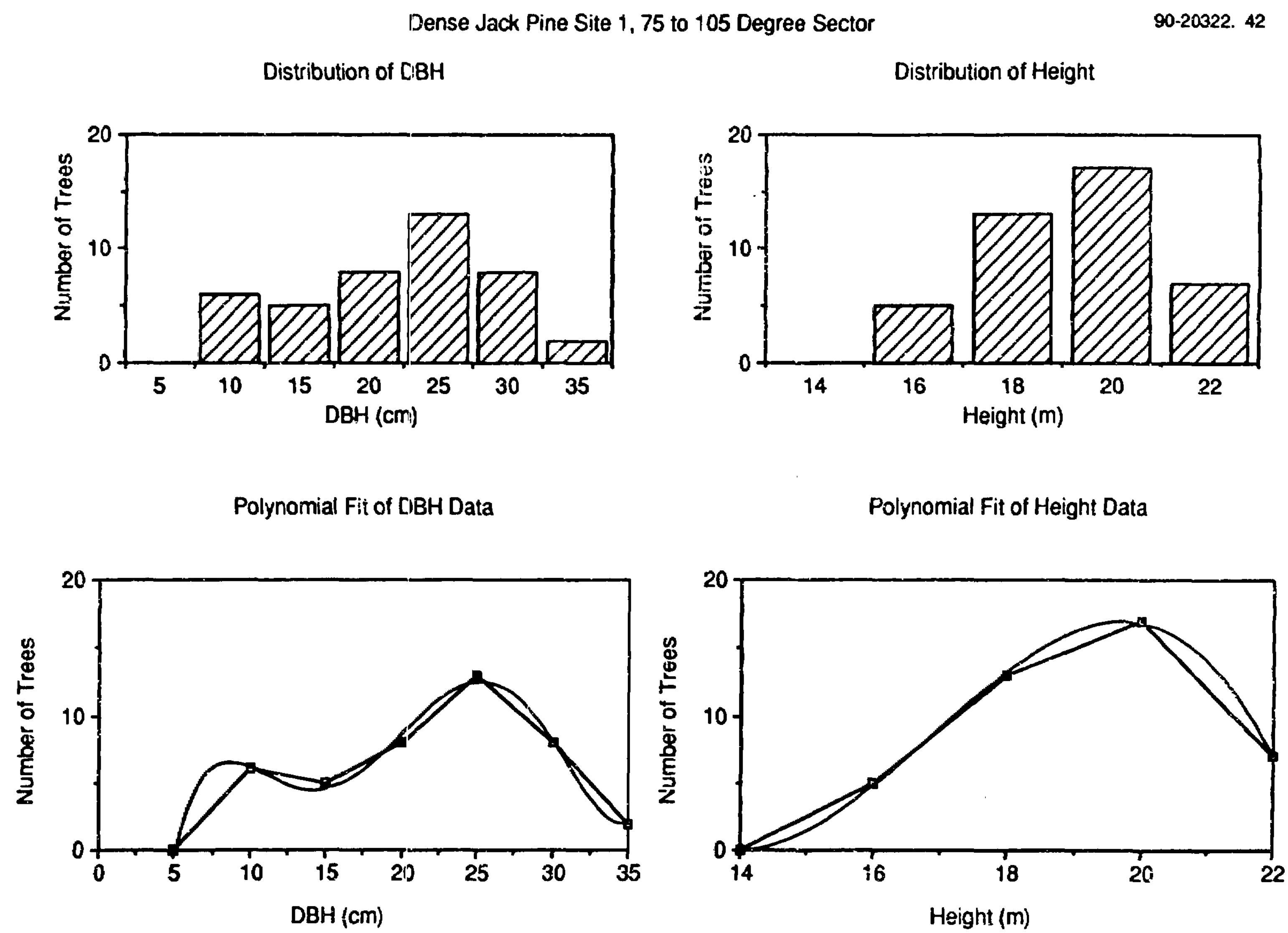


Figure 77 concluded. Histogram Plots of Diameters and Heights and PDF Curves for *Dense Jack Pine Site 1.*

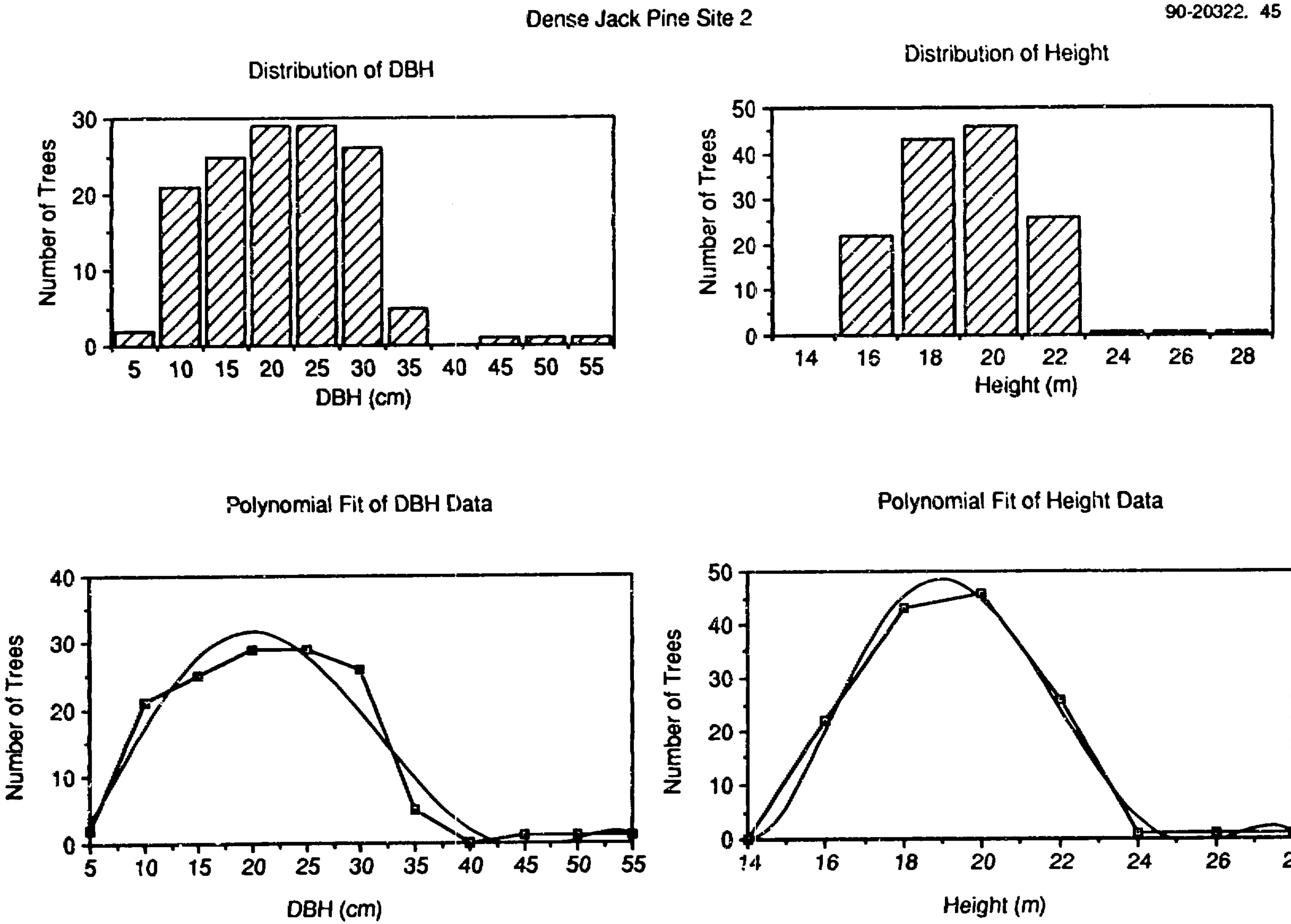


Figure 78. Histogram Plots of Diameters and Heights and PDF Curves for Dense Jack Pine Site 2

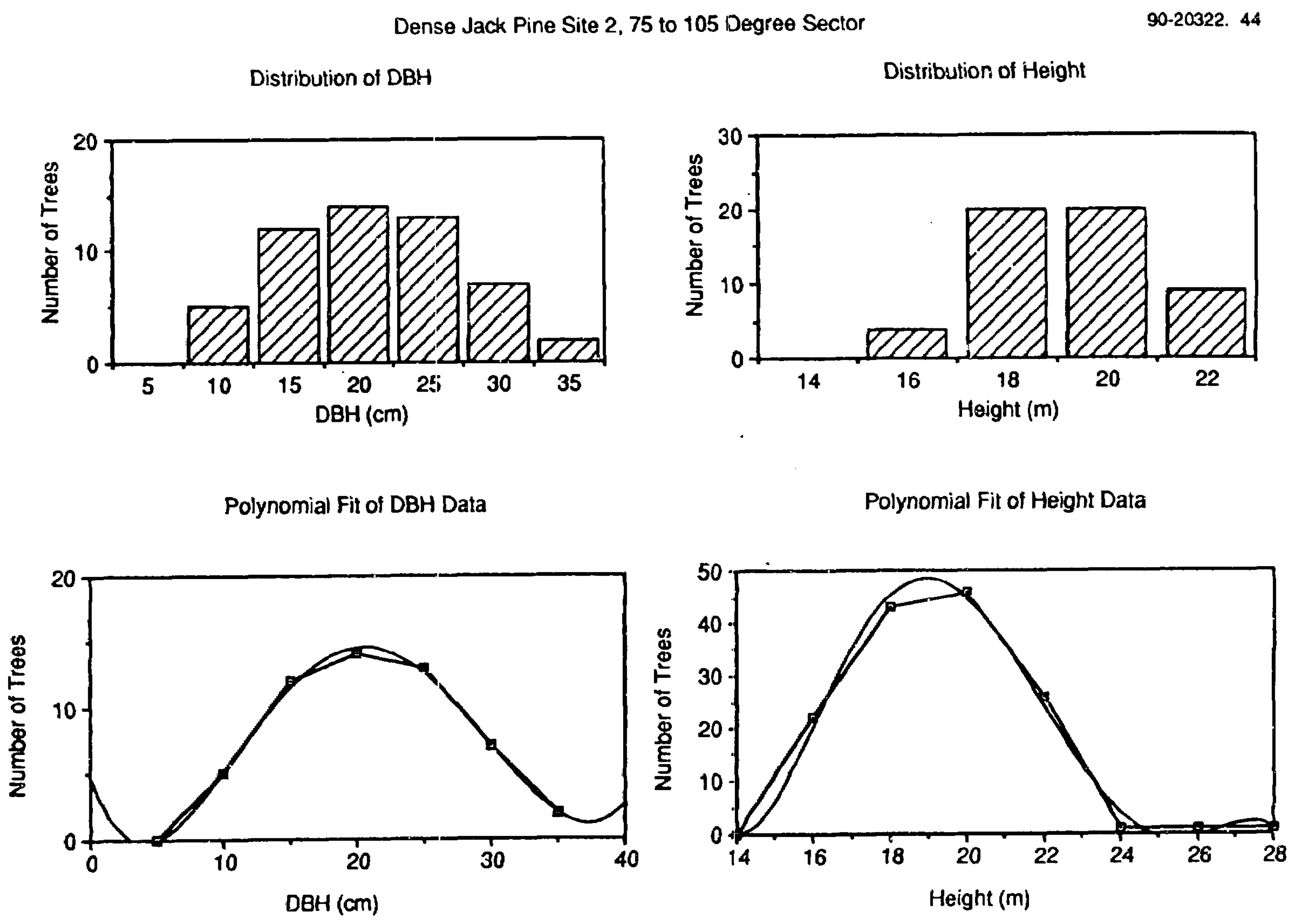


Figure 78 concluded. Histogram Plots of Diameters and Heights and PDF Curves for Dense Jack Pine Site 2.

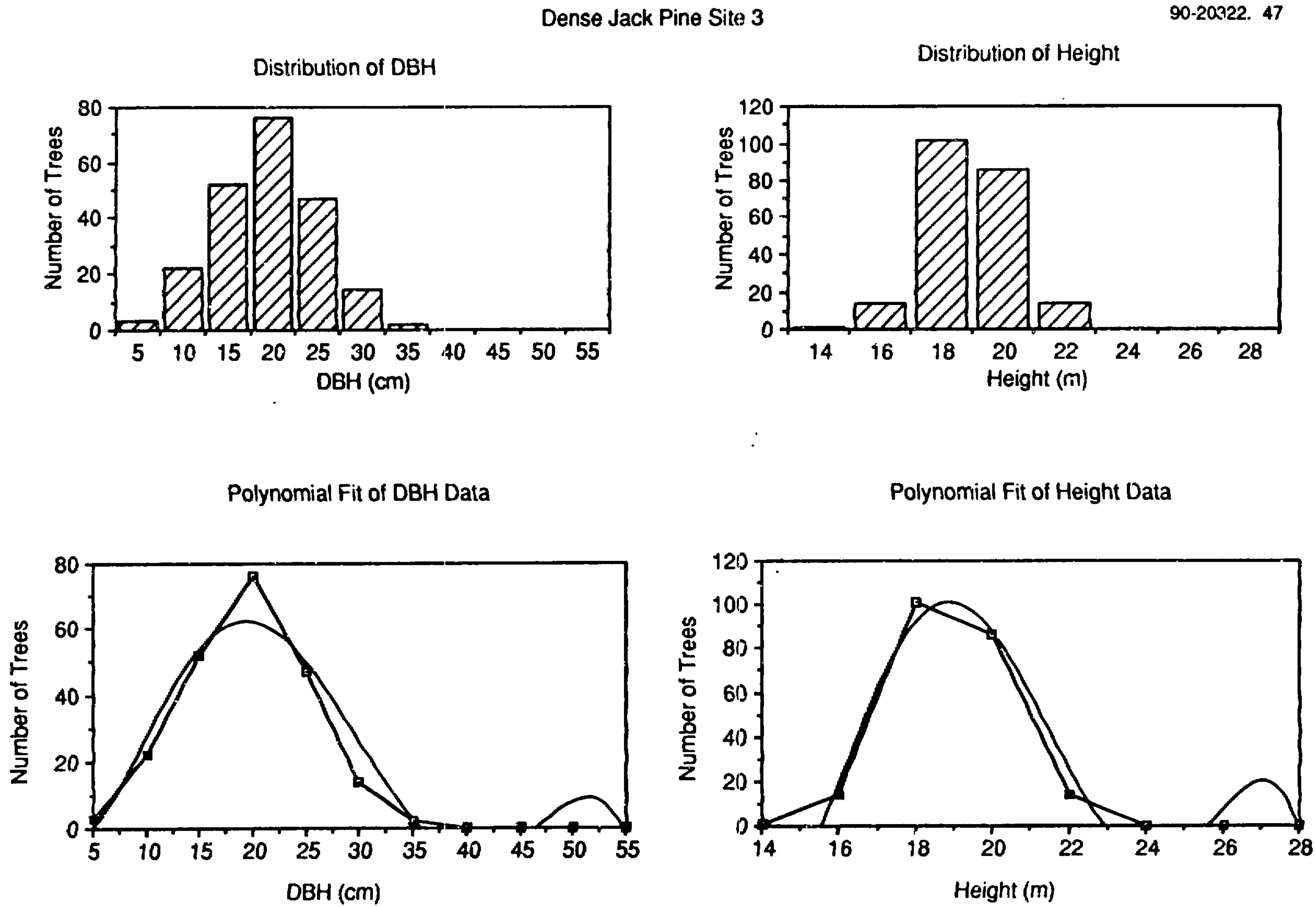


Figure 79. Histogram Plots of Diameters and Heights and PDF Curves for Dense Jack Pine Site 3

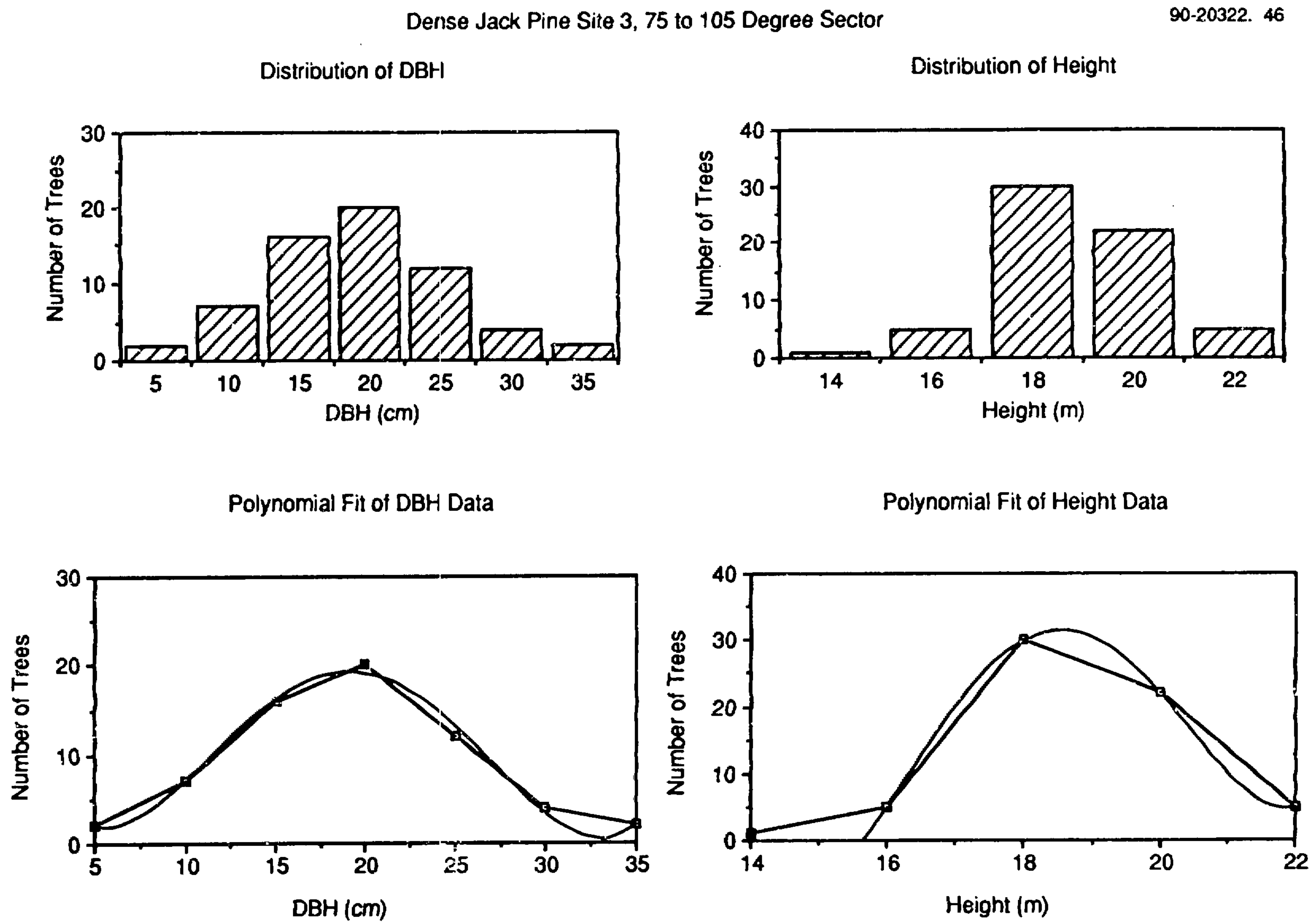


Figure 79 concluded. Histogram Plots of Diameters and Heights and PDF Curves for Dense Jack Pine Site 3.

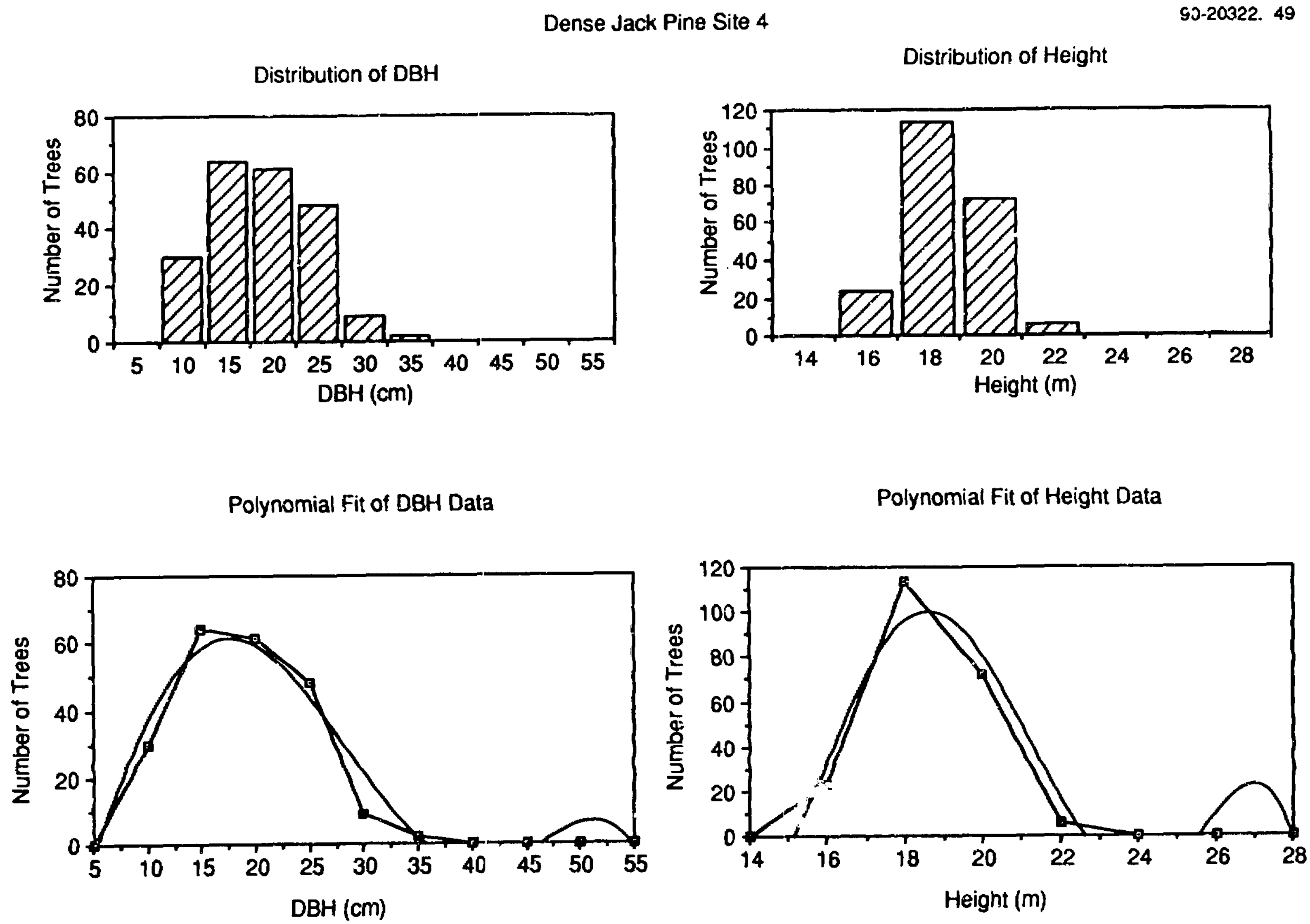


Figure 80. Histogram Plots of Diameters and Heights and PDF Curves for Dense Jack Pine Site 4

Dense Jack Pine Site 4, 75 to 105 Degree Sector

90-20322. 48

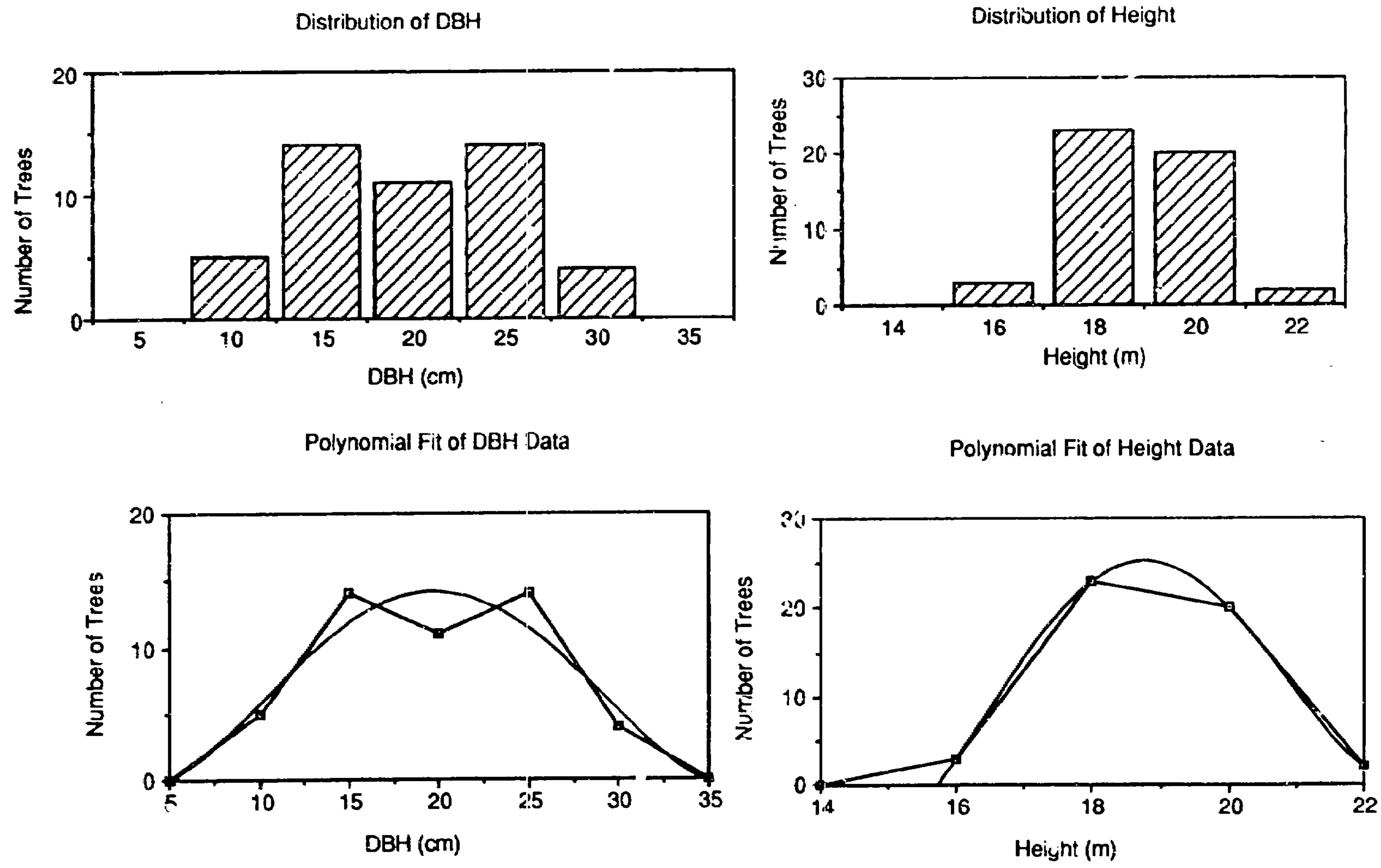


Figure 80 concluded. Histogram Plots of Diameters and Heights and PDF Curves for Dense Jack Pine Site 4.

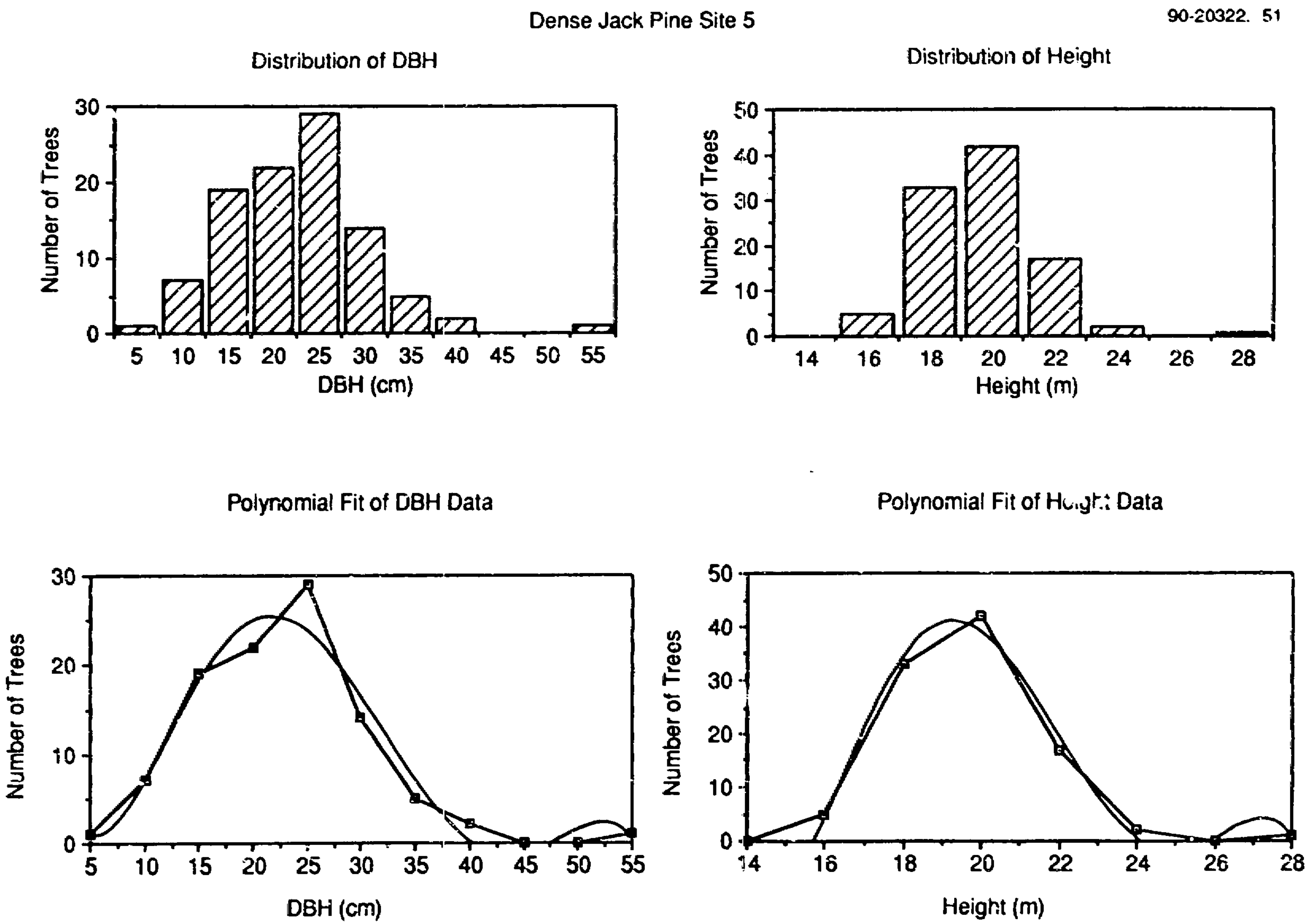


Figure 81. Histogram Plots of Diameters and Heights and PDF Curves for Dense Jack Pine Site 5

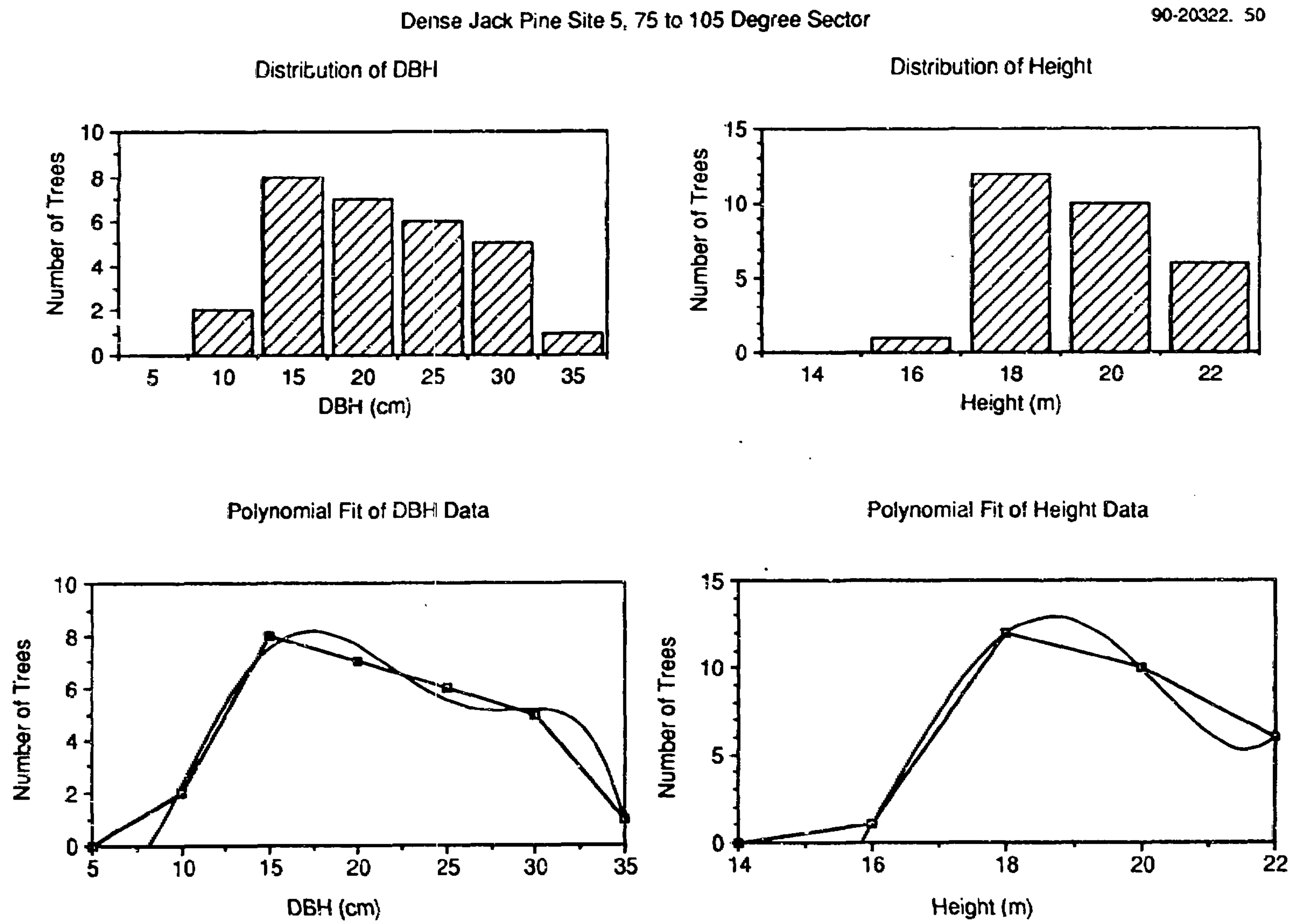


Figure 81 concluded. Histogram Plots of Diameters and Heights and PDF Curves for Dense Jack Pine Site 5.

TABLE 21

SUMMARY OF POLYNOMIAL EQUATIONS FOR DIAMETER AND HEIGHT PDFS FOR THE DENSE JACK PINE STANDS

Entire Stand:

Diameter: x = tree diameter in cm

$y=-8.060-16412x+5.0529x^2-0.28496x^3+.0058494x^4-4.0718*10^{-5}x^5$
$R^2=0.980$

Height: x = tree height in m

$y=252660.0-64397.0x+6429.2x^2-314.38x^3+7.5391x^4-.071054x^5$
$R^2=0.979$

Reflector Site 1:

All trees

Diameter: x = tree diameter in cm

$y=6.6364-4.4922x+0.89330X^2-.045459x^3+8.8182*10^{-4}x^4-5.8974*10^{-6}x^5$
$R^2=0.953$

Height: x = tree height in m

$y=32811.0-8340.9x+829.81x^2-40.398x^3+0.96389x^4-.0090345x^5$
$R^2=0.993$

75 to 105 degree sector

Diameter: x = tree diameter in cm

$y=-64.000+24.395x-3.1033x^2+0.17894x^3-.0046909x^4+4.5333*10^{-5}x^5$
$R^2=0.992$

Height: x = tree height in m

$y=782.54-146.56+8.9554x^2-0.17708x^3$
$R^2=0.999$

TABLE 21 (continued)

SUMMARY OF POLYNOMIAL EQUATIONS FOR DIAMETER AND HEIGHT PDFS FOR THE DENSE JACK PINE STANDS

Reflector Site 2:

All trees

Diameter: x = tree diameter in cm

$$y=-3.7576-0.27385x+0.45390x^2-.026976x^3+5.4289*10^{-4}x^4-3.6410*10^{-6}x^5$$
$R^2=0.937$

Height: x = tree height in m

$$y=19234.0-4913.8x+489.56x^2-23.780x^3+0.56434x^4-.0052484x^5$$
$R^2=0.991$

75 to 105 degree sector

Diameter: x = tree diameter in cm

$$y=4.5714-2.6791x+0.44500x^2-.020197x^3+3.2121*10^{-4}x^4-1.3333*10^{-6}x^5$$
$R^2=0.996$

Height: x = tree height in m

$$y=9590.0-2148.3x+177.66x^2-6.4271x^3+.085938x^4$$
$R^2=1.000$

Reflector Site 3:

All trees

Diameter: x = tree diameter in cm

$$y=14.000-10.686x+2.1142x^2-0.11211x^3+.0022734x^4-1.5846*10^{-5}x^5$$
$R^2=0.925$

Height: x = tree height in m

$$y=88595.0-22535.0x+2247.1x^2-109.84x^3+2.6353x^4-.024860x^5$$
$R^2=0.958$

75 to 105 degree sector

Diameter: x = tree diameter in cm

$$y=18.429-7.0164x+0.92500x^2-.038687x^3+5.0303*10^{-4}x^4$$
$R^2=0.991$

Height: x = tree height in m

$$y=21477.0-4859.0x+406.81x^2-14.938x^3+0.20313x^4$$
$R^2=1.000$

TABLE 21 (concluded)

SUMMARY OF POLYNOMIAL EQUATIONS FOR DIAMETER AND HEIGHT PDFS FOR THE DENSE JACK PINE STANDS

Reflector Site 4:

All trees

Diameter: x = tree diameter in cm

$$y=-44.667+7.0982x+0.50428x^2-.051049x^3+.0012424x^4-9.4359*10^{-6}x^5$$
$R^2=0.951$

Height: x = tree height in m

$$y=31167.0-20862.0x+2101.1x^2-103.67x^3+2.5089x^4-.023858x^5$$
$R^2=0.922$

75 to 105 degree sector

Diameter: x = tree diameter in cm

$$y=1.1429-1.5623x+0.33167x^2-.014808x^3+1.8788*10^{-4}x^4$$
$R^2=0.897$

Height: x = tree height in m

$$y=13895.0-3112.9x+257.63x^2-9.3333x^3+0.12500x^4$$
$R^2=1.000$

Reflector Site 5:

All trees

Diameter: x = tree diameter in cm

$$y=19.727-8.0582x+1.0872x^2-.049365x^3+9.0886*10^{-4}x^4-5.8974*10^{-6}x^5$$
$R^2=0.950$

Height: x = tree height in m

$$y=30118.0-7553.2x+741.84x^2-35.686x^3+0.84209x^4-.0078125x^5$$
$R^2=0.990$

75 to 105 degree sector

Diameter: x = tree diameter in cm

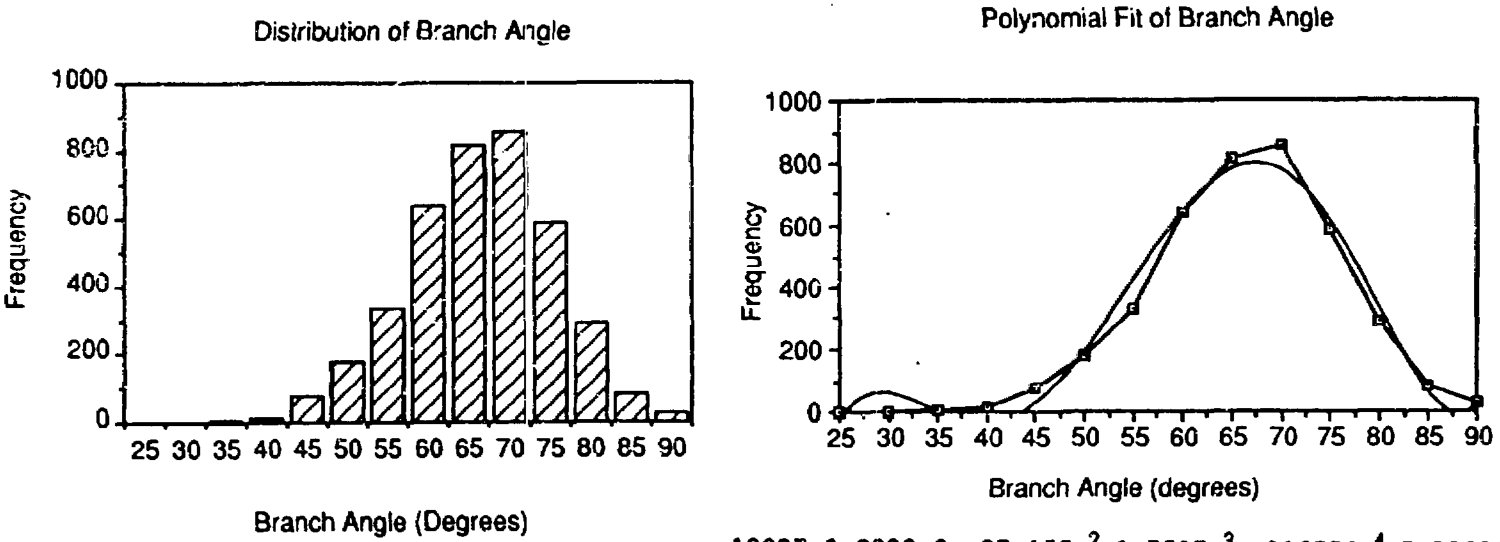
$$y=31.143-13.108x+1.8500x^2-0.10868x^3+.0028606x^4-2.8000*10^{-5}x^5$$
$R^2=0.985$

Height: x = tree height in m

$$y=9345.0-2113.0x+176.90x^2-6.5000x^3+.088542x^4$$
$R^2=1.000$

Frequency of P. Banksiana Branch Angle

90-20322. 54



$y=-18037.0+2038.9x-87.155x^2+1.7537x^3-.016554x^4+5.8969*10^{-5}x^5$
$R^2=0.979$

Figure 82. Histogram Plot and PDF Curves for Jack Pine Branch Angles

Minnesota, Ontario, and Quebec to produce these geographically generalized equations.

	Group one equations	Group two equations
Total mass	$Y = .0726\ D^{2.091} \times H^{0.435}$	$Y = .1054\ D^{2.381}$
Total live mass	$Y = .0601\ D^{2.090} \times H^{0.490}$	$Y = .0911\ D^{2.418}$
Live branch mass	$Y = .0212\ D^{3.839} \times H^{-1.884}$	$Y = .0094\ D^{2.493}$
Dead branch mass	$Y = .0663\ D^{1.791} \times H^{-0.0427}$	$Y = .0517\ D^{1.462}$
Needle mass	$Y = .1159\ D^{2.778} \times H^{-1.498}$	$Y = .0471\ D^{1.664}$

Where Y = biomass (kg), D = diameter at breast height (cm), and H =height (m)

Doucet, Berglund, and Farnsworth (1976) studied dry matter production data in jack pine stands of an average age of 43.5 years growing at three density levels on two sites. The sites were located in the Mattawin river basin at an elevation of 420 meters above sealevel. The stands originated after a fire in 1923. The sites were on a deep deposit of sand of fluvio-glacial origin. The soil was an Orthic Humoferric Podzol.

They developed allometric equations relating diameter and height to live branch biomass, dead branch biomass, needle biomass, and total biomass for two site indexes, one good and the other medium.

Equations for the good site

Live branches	$\text{Log } Y = 0.525747 + 2.574138 \text{ Log } D + 0.210360 \text{ Log } H$
Dead branches	$\text{Log } Y = -2.703526 + 0.187033 \text{ Log } D + 5.083131 \text{ Log } H$
Needles	$\text{Log } Y = -0.043127 + 2.106884 \text{ Log } D + 0.898278 \text{ Log } H$
Total	$\text{Log } Y = 1.053679 + 1.636275 \text{ Log } D + 1.043737 \text{ Log } H$

Equations for the medium site

Live branches	Log Y =	1.237128 + 4.539180 Log D - 2.280269 Log H
Dead branches	Log Y =	1.294463 + 2.826062 Log D - 0.943957 Log H
Needles	Log Y =	0.077329 + 4.008232 Log D - 0.914902 Log H
Total	Log Y =	1.752336 + 2.447128 Log D + 0.196253 Log H

Where Y = biomass in grams, D = diameter at breast height in cm, and H = height in m.

MacLean and Wein (1976) studied a series of pure jack pine stands of fire origin and age range of 7 to 57 years in northeast New Brunswick to determine biomass accumulation after fire. The region lies within the Maritime Plain, elevation of the gently rolling terrain ranges from 15-170 meters. The bedrock consists of red to grey sandstone, conglomerate, and siltstone, but almost all upland is overlain with glacial till.

They developed allometric relations between diameter and total aboveground biomass, stem biomass and crown biomass:

Total

$$\text{Log } Y = -0.660 + 1.940 \text{ Log } D$$

Stem

$$\text{Log } Y = -0.9732 + 2.1366 \text{ Log } D$$

Crown

$$\text{Log } Y = -1.030 + 1.660 \text{ Log } D$$

Where Y = biomass in 10^4 kg/ha and D = diameter at breast height in cm.

Hegyi (1972) conducted a study to provide dry matter distribution data for jack pine and to define how age affects dry matter production in jack pine stands. The study was carried out in two areas in Ontario: 1) Wells Township and 2) West of Black Sturgeon Lake. The database consisted of natural jack pine stands. Twelve stands were selected in area 1 representing three age classes (11-20, 21-30, and 56-65). Four stands were selected in area 2 representing the age class of 65-100 years. They developed regression equations to estimate total tree biomass, total live crown biomass, stem biomass, and needle biomass:

Total Tree

$$\text{Log } Y = -1.0368 + 2.4206 \text{ Log } D$$

Total live Crown

$$\text{Log } Y = -1.1810 + 1.9222 \text{ Log } D$$

Stem

$$\text{Log } Y = -1.5481 + 2.7144 \text{ Log } D$$

Needles

$$\text{Log } Y = -1.4289 + 1.7188 \text{ Log } D$$

4.0 DIELECTRIC MEASUREMENTS

The final tree stand characteristic used in modeling of microwave backscatter discussed in this report are dielectric constants. There are two classes of dielectric constants which are important: (1) the constituents of the trees themselves; and (2) the soil/ground layer. It was our intent to measure both of these categories as part of this effort, but unseasonally cold weather conditions (sub-zero weather and snow) precluded measurement of the soil/litter layer during the November 1989 field trip. Thus, in this section, we will discuss the dielectric measurements made for the different tree species present at the ALP site.

At the time of the ALP data collection in 1988, ERIM had just obtained a set of X, C and L-band field portable dielectric probes from Applied Microwave Corporation of Lawrence, Kansas. These instruments measure the reflection coefficient from a coaxial probe tip which is terminated by the medium being measured. The probe tips used by these devices were 0.358 cm in diameter, resulting in an effective sensing volume extending to a maximum of .18 cm from the tip at L-band. Thus, these tips are not suitable for measuring small or thin tree parts such as twigs, needles and leaves. Other means have to be utilized to estimate these parameters. One approach is to utilize theoretical mixing models, as was done by Dobson et al. (1989).

For this study, we focused on measuring the dielectric constants of the trunks or boles of the tree. The dielectric constant for a tree trunk is not constant, but varies with depth into the trunk. To understand the causes of this variation, one must understand the basic physiology of a tree trunk.

Figure 83 presents a simplified cross section of a tree trunk. The outermost layer of a trunk is the bark layer. This layer can be very thin, on the order of a few millimeters (for example, birch or aspen trees) to tens of centimeters (for example, western pines). The composition of the bark layer always varies between tree species.

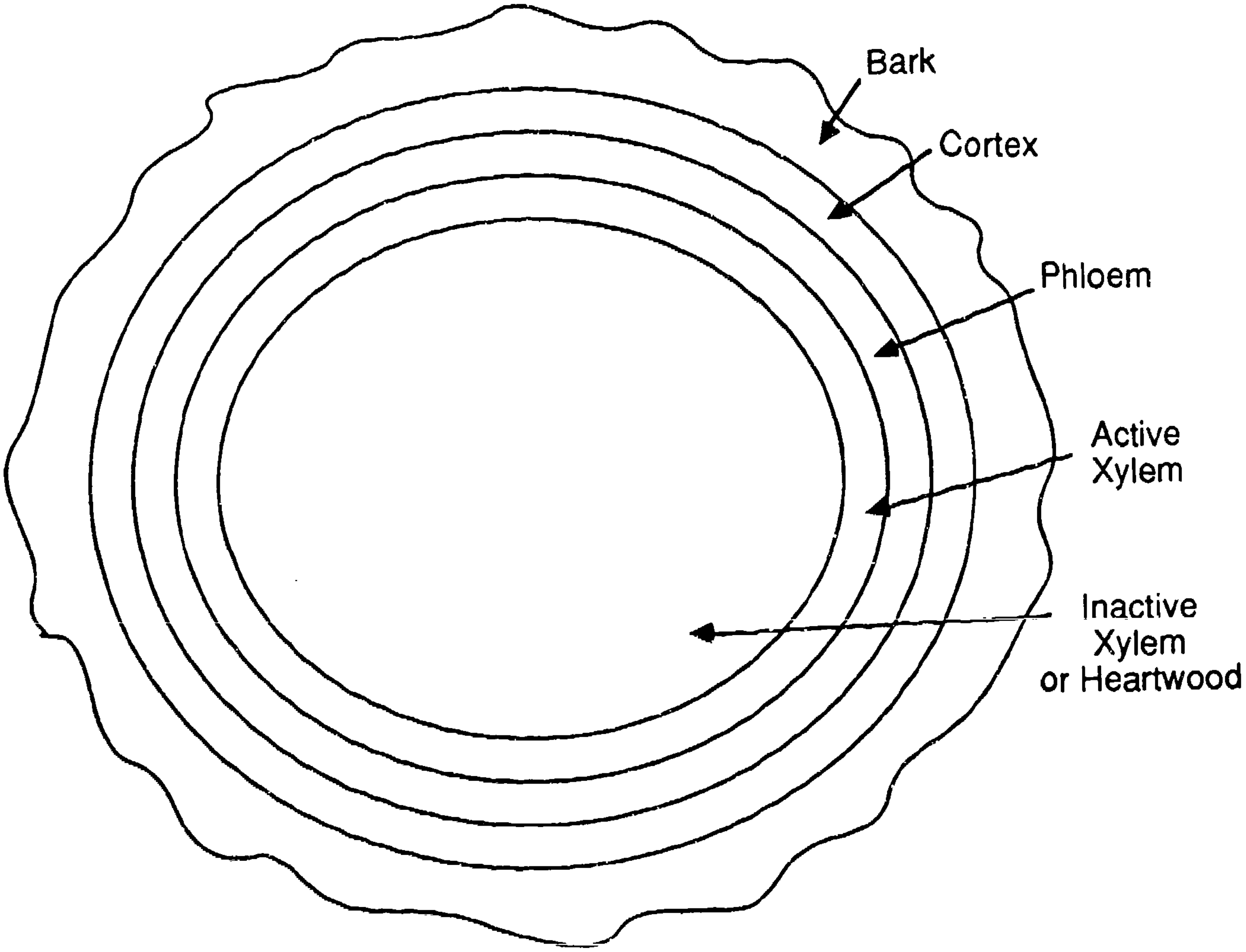


Figure 83. Schematic Diagram of Tree Trunk Cross Section

Immediately adjacent to the inside of the bark lies the cortex layer, often referred to as the cork cambium layer. This layer is comprised of inactive phloem cells. The next layer, which is usually only several millimeters thick, is the phloem layer. The cells in this layer conduct photosynthates produced in the leaves or needles to the rest of the tree. On the inside of the phloem layer is the xylem layer. It is through the xylem cells that fluids (primarily water) are transported from the roots throughout the rest of the tree. Xylem cells actually make up the entire core of the tree, with the outer xylem cells being active in fluid transport. Depending on the tree species, this active layer can be several millimeters to several centimeters thick.

With respect to utilizing the field dielectric probes, the following layers can be interrogated with the probe:

1. The bark layer;
2. The outside of the phloem layer, just to the inside of the cortex. Because this layer is often less than .10 cm thick, the outer xylem layer is also influencing the dielectric constant measurement;
3. The inside of the phloem layer. The phloem layer can often be clearly separated or stripped away from the outer xylem layer.
4. Various depths of the xylem layer.

There is a certain degree of skill needed to collect dielectric constants from trees using the field portable probes. First, one must develop an understanding of the location of the various trunk layers of interest for a specific tree species. Next, one must also learn how to prepare a tree for sampling, which often requires carefully removing the outer layers of bark and cortex in order to reach the outer layer of phloem, without damaging the phloem layer. Then, in some cases, the tree will have a response (such as the release of resin) in response to the scraping away of outer plant tissue), which will require obtaining the sample quickly. Finally, because the dielectric measurement is sensitive to overall liquid content of the sample being measured, it is

important that the data collector does not physically alter the tree layer being sampled by pressing too hard with the dielectric probe.

In design of an experiment to collect dielectric data for the ALP tree species, the following objectives were defined:

1. Data had to be collected during the same season as the ALP data were collected;

2. The dielectric profiles of the two major tree species present in the ALP test site (aspen and jack pine) had to be established at all three frequencies;

3. Adequate data to define the between tree variation for the critical layers had to be collected; and

4. Diurnal variations within the different tree species had to be defined.

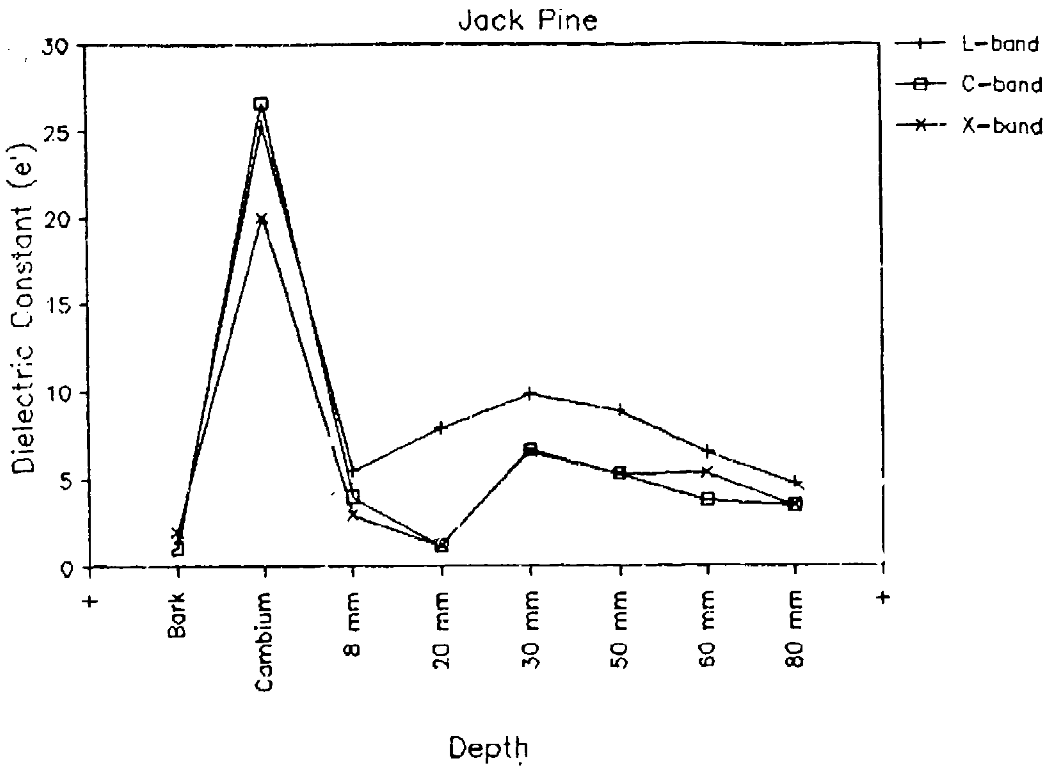
In order to achieve the above objectives, the following experiment was defined: A test site was located in northern Michigan (near Pellston), which was at the same approximate latitude and elevation as the ALP test site. This area contained extensive stands of both jack pine and aspen under the same soil conditions. Thus, the trees in this site were expected to be quite similar in all aspects to those found at the ALP test site. Because of time constraints, an experiment was conducted in early October, 1990 in order to collect tree dielectric data. At this time, most of the aspen trees were well into their fall senescence, thus no active photosynthesis was present in the aspen trees. However, the jack pines were still photosynthetically active, and thus some diurnal variation in the dielectric constant could be expected. Dielectric profiles at X, C and L-bands were collected from several trees in each species categories. The tree selected for these profiles were approximately 16 cm in diameter, and 15 to 20 m in height.

For the aspens, bark and cambium dielectric constants were collected from approximately 20 different trees during one afternoon time period when the temperatures were near 24° C. For the jack pine trees, bark

dielectric constants were collected during one time period, while cambium dielectric constants were collected at three separate times. These three separate times consisted of the following conditions:

1. Day 1 (PM) - Sunny, Breezy, 24° C.
2. Day 2 (AM) - Cloudy, 13° C.
3. Day 3 (PM) - Cloudy, Breezy, 13° C.

All the dielectric measurements collected during this experiment are summarized in Appendix C. Based on the measurements, no variations in the dielectric constants from the jack pine cambium layers were found. In Figures 84 and 85, we present the dielectric constant profiles for the jack pine and aspen trees. Note that the values presented in these figures represent average values. The bark and cambium average values were obtained from all samples collected, while the rest of the averages came from the two trees.



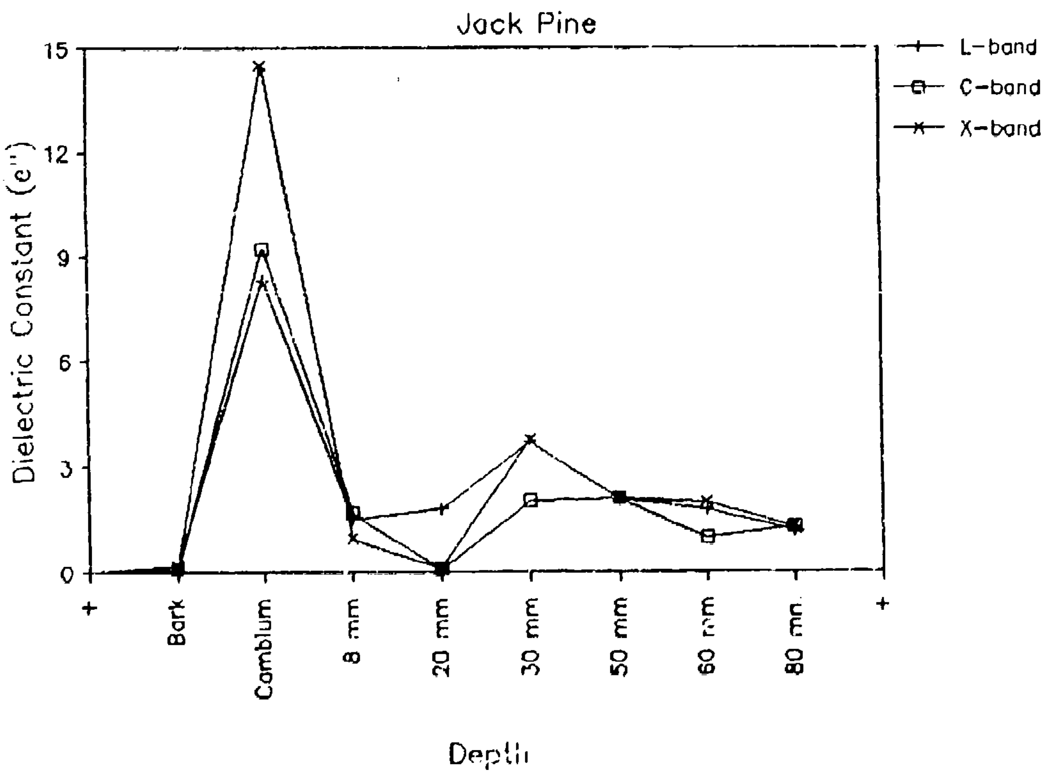
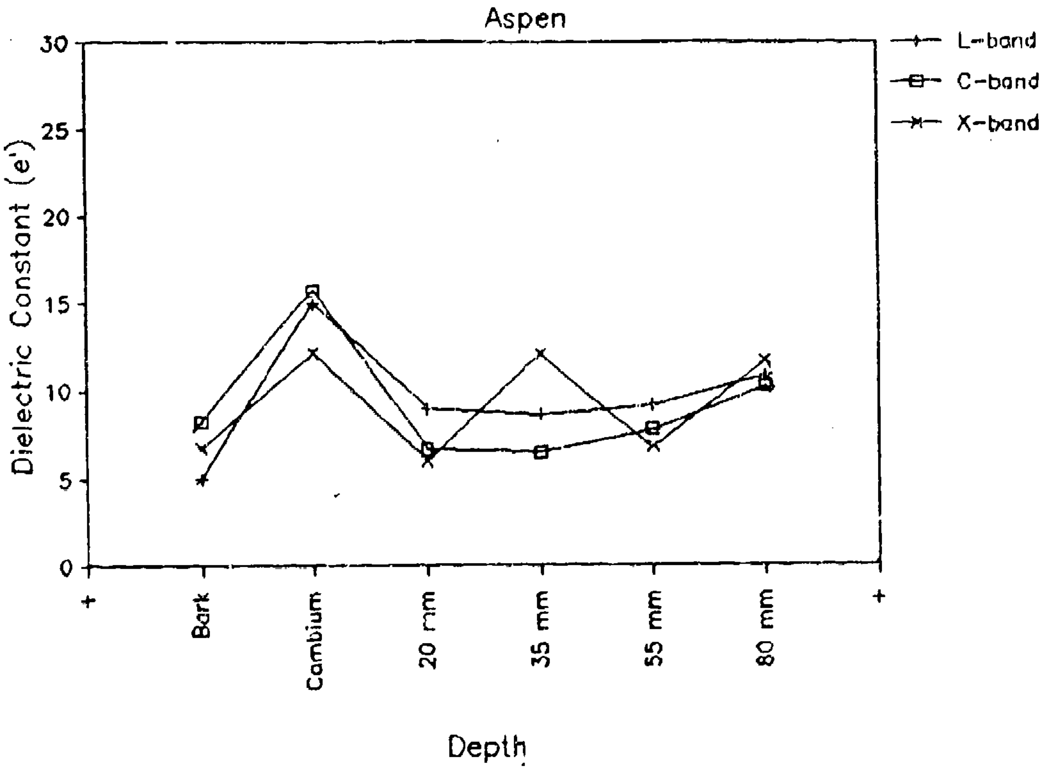


Figure 84. Dielectric Constant Profiles for Aspen Trees



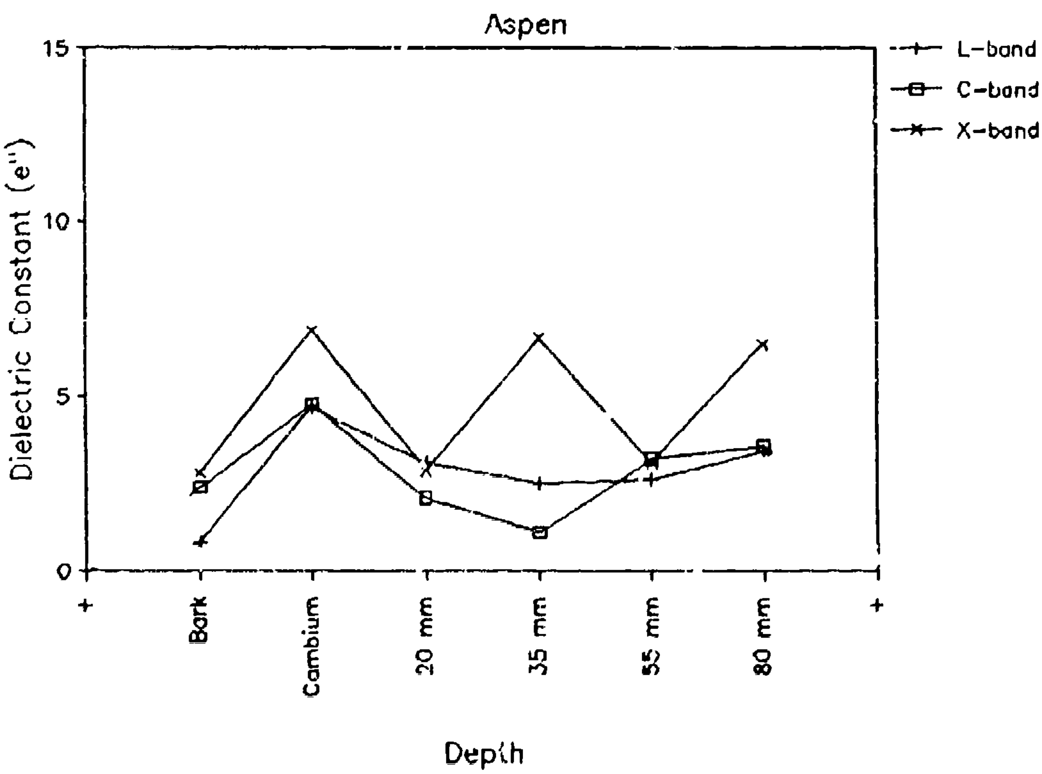


Figure 85. Dielectric Constant Profiles for Jack Pine Trees

5.0 REFERENCES

Bray, J.R. and L.A. Dudkiewicz, The composition, biomass and productivity of two Populus forests, Bull. Torrey Bot. Club, 90: 298-308, 1963.

Burke, T.E., N.D. Nelson, and J.G. Isebrands, Crown architecture of short-rotation, intensively cultured Populus. III. A model of first-order branch architecture, Can. Jour. For. Res., 13: 1107-1116, 1983.

Cimino, J.B., D. Casey, N. Christensen, M.C. Dobson, F. Ulaby, E. Kasischke, J. Richards, C. Slaughter and L. Viereck, The Effect of Changing Environmental Conditions on Microwave Signatures of Forest Ecosystems, Int. J. Remote Sensing, in press, 1990.

Dobson, M.C., K. McDonald, F.T. Ulaby and J.F. Paris, Diurnal Patterns in Multifrequency, Multipolarization Backscattering from a Walnut Orchard, Proc. Int. Geosci. Remote Sens. Symp., Edinburgh, UK, P. 1755, 1988.

Dobson, M.C., K. McDonald, and F.T. Ulaby, Modeling of Forest Canopies and Analysis of Polarimetric SAR Data, University of Michigan Technical Report 026143-1-F, Ann Arbor, MI, 174 pp., 1989.

Doucet, R., J.V. Berglund and C.E. Farnsworth, Dry matter production in 40-year-old Pinus banksiana stands in Quebec. Can. J. For. Res. 6: 357-367, 1976.

Green, D.C., and D.F. Grigal, Generalized biomass estimation equations for jack pine (Pinus banksiana Lamb). Minnesota Forestry Research Notes. ed. E. Sucoff. St. Paul, MN. no.268, 4 pp., 1978.

Hegyi, F., Dry matter distribution in jack pine stands in northern Ontario. The Forestry Chronicle 48: 193-197, 1972.

Isebrands, J.G. and N.D. Nelson, Crown architecture of short-rotation, intensively cultured Populus II. Branch morphology and distribution of leaves within the crown of Populus 'Tristis' as related to biomass production. Can. Jour. For. Res. 12: 853-864, 1982.

Kasischke, E.S., Unpublished data from a February, 1989 Duke Forest data collection, 1989.

Kasischke, E.S., D. Beverstock, C.A. Russel, M. Craig Dobson and K.C. McDonald, X- and C-Band Forest Extinction Study, ERIM Technical Report, 65 pp., April, 1989.

Lewis, T., N. Subotic, J. Gorman, and E. Kasischke, Foliage Penetration Radar Study, Final Report SARIT Task I, ERIM Report No. 211000-6-F, Ann Arbor, MI, 1990.

MacLean, D.A., and R.W. Wein, Biomass of jack pine and mixed hardwood stands in northeastern New Brunswick. Can. Jour. For. Res. 6: 441-447, 1976.

Nelson, N.D., T. Burk, and J.G. Isebrands, Crown architecture of short-rotation, intensively cultured Populus. I. Effects of clone and spacing on first-order branch characteristics. Can. Jour. For. Res. 11: 73-81, 1981.

Polk, R.B., Heritabilities of some first-order branching traits in Pinus banksiana Lamb. Proceedings of the 8th Central States Forest Tree Improvement Conference. University of Missouri, Columbia pp. 33-39, 1974.

Schlaegel, B.E., Yields of Four 40-year-old Conifers and Aspen in Adjacent Stands. Can. Jour. For. Res. 5: 278-280, 1975.

Sullivan, R.J., G.F. Adams, [illegible] Auch, E.S. Kasischke and D.R. Sheen, Collection and Processing of Airborne SAR Data from a Forested Region (Volume 1), ERIM Final Report No. 211000-2-T, Ann Arbor, MI, 22 pp., 1989.

Zavitkovski, J., Dry weight and leaf area of aspen trees in northern Wisconsin. Forest biomass studies. ed. H. Young. University of Maine Press. Orono, ME. pp. 193-205, 1971.

APPENDIX A

SURFACE PHOTOGRAPHS OF FOPEN TEST SITES

To aid in interpretation of the FOPEN data, a set of surface photographs were collected. This photography was collected on three different dates: (1) during October 1988, during the P-3 SAR data collections; (2) in May of 1989, during a second visit to the site; and (3) in early November of 1989, during a second visit to this site.

Several different sets of photographs were collected at each site:

1. From the location of the bottom rear of the corner reflector, a view towards the east, with the camera pointed horizontal, and 20° to 40° above the horizon. Recall, the SAR was "looking" towards the west during most of the data collections. Thus, these photographs capture one view of the trees through which the radar waves passed;

2. A horizontal view of the target location looking from the north, west and east in order to capture the general ground cover conditions, as well as the closeness of the trees to the target; and

3. For the medium and dense aspen stands, a view towards 304° which corresponds to the look direction used during the clutter passes.

In this appendix, the surface photographs are presented in the following order:

Sparse Aspen Sites

Medium Aspen Sites

Dense Aspen Sites

Sparse Jack Pine Sites

Medium Jack Pine Sites

Dense Jack Pine Sites

LIST OF FIGURES

LIST OF FIGURES (concluded)

APPENDIX B

FOPEN STAND DATA

In this appendix, we present a summary of all data which were collected during the ground truth activities. In summary, the following tables are presented:

Tables B1 to B4	Sparse Aspen Stand Data
Tables B5 to B7	Medium Aspen Stand Data
Tables B8 to B10	Dense Aspen Stand Data
Tables B11 to B15	Sparse Jack Pine Data
Tables B16 to B17	Medium Jack Pine Data
Tables B18 to B19	Dense Jack Pine Data

APPENDIX B

LIST OF TABLES

APPENDIX B

LIST OF TABLES (continued)

TABLE B1

SUMMARY OF THE NUMBER OF TREES WITH DIAMETERS
LESS THAN 1.3 cm FOR THE SPARSE ASPEN SITES

Stand	Height	Transect 1	Transect 2
1	< 1.2 m	77	91
	> 1.2 m	69	56
2	< 1.2 m	52	51
	> 1.2 m	108	108
3	< 1.2 m	114	87
	> 1.2 m	36	39
4	< 1.2 m	93	56
	> 1.2 m	84	64
5A	< 1.2 m	91	129
	> 1.2 m	101	37
5B	< 1.2 m	64	85
	> 1.2 m	73	64
6	< 1.2 m	111	68
	> 1.2 m	63	79

TABLE B2

SUMMARY OF DIAMETER AND HEIGHT MEASUREMENTS FOR THE SPARSE ASPEN SITE TRANSECTS

SITE: 1

	Diameter (cm)	Height (m)
Transect 1	1.3	1.83
	1.4	2.13
	1.4	2.44
	1.5	2.44
	1.6	2.74
	1.7	2.44
	1.8	2.44
	1.9	3.05
	1.9	3.05
	2.1	3.05
	2.2	3.05
	2.4	3.35
	2.6	3.66
	2.9	4.57
	3.0	3.96
	3.0	4.88
	3.2	3.96
	3.2	4.88
	4.2	4.57
	4.6	4.27

TABLE B2 (continued)

SUMMARY OF DIAMETER AND HEIGHT MEASUREMENTS FOR
THE SPARSE ASPEN SITE TRANSECTS

SITE: 1

	Diameter (cm)	Height (m)
Transect 2		
	1.5	2.44
	1.6	1.52
	1.8	3.05
	1.9	3.05
	1.9	3.35
	2.0	1.83
	2.0	2.44
	2.0	2.74
	2.0	3.05
	2.0	3.35
	2.0	3.66
	2.1	3.05
	2.1	3.66
	2.2	3.35
	2.3	3.66
	2.4	3.05
	2.4	3.66
	2.4	3.66
	2.6	3.35
	2.7	3.66
	2.8	3.05
	2.8	3.66
	2.8	3.66
	2.9	3.96
	2.9	4.27

TABLE B2 (continued)

SUMMARY OF DIAMETER AND HEIGHT MEASUREMENTS FOR THE SPARSE ASPEN SITE TRANSECTS

SITE: 2

	Diameter (cm)	Height (m)
Transect 1	1.3	2.13
	1.3	2.44
	1.4	2.44
	1.4	3.05
	1.6	2.74
	1.6	3.05
	1.8	2.13
	2.0	2.44
	2.1	3.35
	2.5	3.66
	2.6	3.66
	2.6	4.57
	2.8	3.66
	2.8	4.27
	2.9	3.96
	3.0	4.27
	3.4	4.57
	4.0	4.57
	4.2	5.18
Transect 2	1.3	2.13
	1.3	2.44
	1.4	2.13
	1.4	2.44
	1.5	2.44
	1.6	3.05
	1.7	3.05
	1.8	2.44
	1.8	3.66
	2.1	3.66
	2.1	3.66
	2.4	3.05
	2.8	3.96
	2.8	3.96
	2.9	4.27
	3.2	4.57
	3.8	4.27
	3.8	4.27
	4.2	5.18

TABLE B2 (continued)

SUMMARY OF DIAMETER AND HEIGHT MEASUREMENTS FOR
THE SPARSE ASPEN SITE TRANSECTS

SITE: 3

	Diameter (cm)	Height (m)
Transects 1 & 2	1.3	1.83
	1.3	2.74
	1.6	2.44
	1.9	3.05
	2.0	2.44
	2.0	3.05
	2.1	3.05
	2.2	3.05
	2.3	3.35
	2.3	3.35
	2.6	3.35
	2.7	3.05
	2.9	3.05
	2.9	3.66
	3.0	3.66
	3.0	4.27
	1.3	1.83
	1.3	1.83
	1.3	1.83
	1.3	2.74
	1.7	2.13
	1.8	2.74
	2.0	2.74
	2.0	3.66
	2.1	3.35
	2.4	1.52
	2.5	3.66
	2.5	3.66
	2.8	2.44
	2.8	3.66
	2.9	3.05
	3.0	3.66
	3.0	3.66
	3.0	3.66
	3.0	3.96
	3.2	3.66
	4.2	4.27
	4.6	4.57
	4.8	4.27
	4.8	4.57

TABLE B2 (continued)

SUMMARY OF DIAMETER AND HEIGHT MEASUREMENTS FOR
THE SPARSE ASPEN SITE TRANSECTS

SITE: 4

	Diameter (cm)	Height (m)
Transect 1	1.3	2.13
	1.3	2.13
	1.3	2.44
	1.4	2.44
	1.5	3.05
	1.7	3.05
	1.8	3.35
	1.9	3.05
	2.0	3.05
	2.0	3.35
	2.1	3.05
	2.1	3.35
	2.1	3.66
	2.1	3.96
	2.2	3.05
	2.3	3.05
	2.4	4.27
	2.9	3.96
	2.9	3.96
	2.9	4.27
	3.0	3.96
	3.0	3.96
	3.0	4.27
	3.4	4.57
	3.6	4.27

TABLE B2 (continued)

SUMMARY OF DIAMETER AND HEIGHT MEASUREMENTS FOR
THE SPARSE ASPEN SITE TRANSECTS

SITE: 4

	Diameter (cm)	Height (m)
Transect 2	1.3	2.44
	1.3	2.44
	1.3	2.74
	1.4	2.13
	1.4	2.44
	1.4	2.44
	1.4	2.74
	1.5	2.13
	1.6	2.44
	1.6	3.05
	1.7	3.35
	1.8	3.05
	1.9	3.05
	1.9	3.35
	1.9	3.56
	2.0	3.05
	2.0	3.05
	2.0	3.35
	2.0	3.66
	2.1	3.05
	2.1	3.05
	2.1	3.66
	2.1	3.96
	2.2	3.05
	2.2	3.66
	2.2	3.66
	2.4	3.96
	2.5	3.66
	2.5	3.96
	2.6	3.66
	2.7	3.66
	2.8	3.66
	2.8	3.96
	2.9	3.96

TABLE B2 (continued)

SUMMARY OF DIAMETER AND HEIGHT MEASUREMENTS FOR
THE SPARSE ASPEN SITE TRANSECTS

SITE: 5A

	Diameter (cm)	Height (m)
Transect 1	1.3	1.52
	1.3	2.13
	1.3	2.44
	1.3	2.44
	1.3	2.74
	1.3	2.74
	1.4	2.74
	1.6	2.13
	2.0	2.74
	2.0	2.74
	2.1	3.05
	2.1	3.66
	2.5	3.66
	2.5	4.27
	2.6	3.96
	2.7	3.05
	2.7	3.66
	2.9	3.05
	2.9	3.96
	3.0	3.05
	3.0	3.66
	3.0	4.57
	3.4	4.27
	3.8	4.27
	4.0	3.96
	4.0	4.27
	4.0	4.57
	4.0	4.57

TABLE B2 (continued)

SUMMARY OF DIAMETER AND HEIGHT MEASUREMENTS FOR THE SPARSE ASPEN SITE TRANSECTS

SITE: 5A

	Diameter (cm)	Height (m)
Transect 2	1.3	1.52
	1.3	1.52
	1.3	1.83
	1.3	1.83
	1.5	1.22
	1.5	2.13
	1.7	1.52
	2.0	2.44
	2.0	2.74
	2.0	2.74
	2.1	2.44
	2.3	3.66
	2.4	3.66
	2.5	3.35
	2.6	3.35
	2.7	3.05
	2.9	3.35
	2.9	3.96
	3.0	3.66
	3.2	3.96
	3.8	3.96
	3.8	4.27

TABLE B2 (continued)

SUMMARY OF DIAMETER AND HEIGHT MEASUREMENTS FOR
THE SPARSE ASPEN SITE TRANSECTS

SITE: 5B

	Diameter (cm)	Height (m)
Transect 1	1.3	1.83
	1.3	1.83
	1.3	2.13
	1.3	2.13
	1.4	1.52
	1.6	3.05
	1.7	2.44
	1.7	2.74
	1.9	2.74
	2.0	3.05
	2.0	3.05
	2.1	2.74
	2.1	3.66
	2.1	3.66
	2.1	3.96
	2.4	3.66
	2.8	3.05
	2.9	3.66
	2.9	3.96
	3.0	3.96
	3.0	3.96
	3.8	4.27
	3.8	4.57

TABLE B2 (continued)

SUMMARY OF DIAMETER AND HEIGHT MEASUREMENTS FOR THE SPARSE ASPEN SITE TRANSECTS

SITE: 5B

	Diameter (cm)	Height (m)
Transect 2	1.3	1.83
	1.3	2.74
	1.3	3.05
	1.6	1.83
	1.7	2.44
	1.8	1.83
	1.8	3.05
	1.9	2.13
	2.0	3.05
	2.2	3.05
	2.2	3.05
	2.6	2.74
	2.6	3.66
	2.6	3.66
	2.8	3.66
	2.9	3.66
	3.0	3.35
	3.0	3.35
	3.0	3.66
	3.0	3.66
	3.4	3.96

TABLE B2 (continued)

SUMMARY OF DIAMETER AND HEIGHT MEASUREMENTS FOR THE SPARSE ASPEN SITE TRANSECTS

SITE: 6

	Diameter (cm)	Height (m)
Transect 1	1.3	2.13
	1.4	2.44
	1.4	3.35
	1.5	3.05
	1.7	2.13
	1.7	2.74
	1.8	2.74
	1.8	3.05
	2.1	2.44
	2.1	3.05
	2.1	3.05
	2.1	3.96
	2.4	3.05
	2.8	3.66
	2.9	3.96
	2.9	4.27
	3.0	4.27
	3.2	3.96
	3.2	4.27
	3.6	4.88

TABLE B2 (concluded)

SUMMARY OF DIAMETER AND HEIGHT MEASUREMENTS FOR THE SPARSE ASPEN SITE TRANSECTS

SITE: 6

	Diameter (cm)	Height (m)
Transect 2	1.4	2.13
	1.4	2.74
	1.6	2.74
	1.7	3.05
	1.7	3.05
	1.9	2.74
	2.0	3.05
	2.2	3.96
	2.4	2.74
	2.5	3.35
	2.8	4.27
	2.9	3.66
	2.9	3.96
	2.9	4.27
	3.0	4.27
	3.2	4.27
	3.2	4.27
	3.4	4.27
	3.6	4.57
	4.0	4.57
	4.2	5.18
	4.6	4.88

TABLE B3

SUMMARY OF BOLE DIAMETER (cm) AS A FUNCTION OF HEIGHT FOR INDIVIDUAL TREES FROM THE SPARSE ASPEN STAND

Tree	1	2	3	4
Height (cm)	340	320	310	335
5	3.8	3.0	2.9	2.2
50	3.2	2.7	2.6	2.0
100	2.9	2.4	2.2	1.7
150	2.5	2.1	2.1	1.5
200	2.1	1.5	1.2	1.3
250	1.2	1.2	1.0	.6
300	.6	.3	.2	.3

TABLE B4

TREE BIOMASS DATA FOR FOUR DIFFERENT ASPEN SAPLINGS

Tree	Diameter (cm)	Dry Weight (gm) Stems	Bole	Total
1	2.0	198.5	420.9	619.4
2	1.5	171.6	355.5	527.1
3	1.5	152.2	273.0	425.2
4	1.0	85.5	221.7	307.2

TABLE B5

TREE AND CANOPY HEIGHT MEASUREMENTS FOR
MEDIUM ASPEN STANDS

Diameter (cm)	Height Total (m)	Height of Lowest Living Branch (m)
15.3	17.4	7.3
12.7	17.4	5.5
8.4	14.6	5.5
11.3	13.5	4.6
8.4	14.2	5.0
10.1	13.7	7.3
11.7	14.6	5.5
4.8	7.1	3.2
11.1	11.9	5.5
9.3	11.0	4.6
7.3	9.6	3.7
10.5	12.6	3.2
10.7	14.0	4.4
8.5	11.0	6.4
11.6	14.2	6.9
8.9	13.7	5.5
13.6	19.2	10.1
9.9	14.6	10.5
12.4	14.2	8.9
7.0	12.8	9.6
8.4	11.9	8.7
9.6	15.1	9.1
13.1	11.9	8.7
8.8	11.0	5.9
9.4	12.3	8.7
12.1	16.5	8.2
8.9	13.7	9.1
6.9	10.1	7.3
8.1	12.2	6.9
9.5	11.0	
9.8	11.9	
11.8	13.7	
8.1	12.3	
8.7	10.1	
4.3	7.3	
8.0	11.0	
5.7	8.2	
5.2	8.6	
6.8	8.2	
5.6	7.6	

TABLE B5 (concluded)

TREE AND CANOPY HEIGHT MEASUREMENTS FOR MEDIUM ASPEN STANDS

Diameter (cm)	Height Total (m)	Height of Lowest Living Branch (m)
10.5	13.0	
7.9	10.5	
5.0	8.7	
4.8	9.1	
10.9	11.4	
7.3	12.3	
7.8	12.3	
6.3	5.9	
6.5	8.7	
14.8	19.5	
12.3	16.9	
12.4	15.5	
14.5	15.5	
10.9	13.7	
10.3	14.2	
8.0	14.2	
11.4	15.1	
11.0	14.2	
8.3	11.4	
9.2	12.8	
4.7	9.0	
6.8	9.0	
11.1	13.7	
9.0	14.0	
7.2	9.1	
11.5	14.2	
5.5	6.4	
8.9	15.1	
4.5	7.8	
7.2	6.6	
8.0	13.7	
8.7	10.1	
6.2	9.1	
8.9	12.3	
10.2	12.8	
7.1	9.8	
9.5	13.7	
7.8	10.5	
9.9	12.8	

TABLE B6

SUMMARY OF MEDIUM ASPEN STAND TRANSECT DATA

Site	Transect	Trees/ Hectare	Diameter (cm) Average	Diameter (cm) Std	Height (m) Average	Height (m) Std
1	CENTER	3861	6.38	4.06	10.87	3.36
1	CROSS	7755	5.96	2.53	9.13	2.47
1	SOUTH	4356	5.50	3.53	9.10	2.48
1	NORTH	5743	6.40	2.65	8.68	3.45
1	TOTAL SITE	5085	5.98	3.30	9.35	3.08
2	CENTER	4059	5.57	3.04	8.74	2.98
2	CROSS	3469	5.49	2.32	8.67	2.27
2	SOUTH	3663	6.76	2.89	9.91	2.82
2	NORTH	1881	5.65	2.71	8.82	2.65
2	TOTAL SITE	3239	5.96	2.89	9.12	2.83
3	CENTER	3465	7.75	2.67	10.88	2.61
3	CROSS	4286	7.92	3.20	11.05	3.13
3	SOUTH	4752	7.19	2.45	10.33	2.40
3	NORTH	5941	6.96	3.07	10.10	3.00
3	TOTAL SITE	4659	7.32	2.86	10.45	2.79
4	CENTER	3366	5.74	2.10	8.92	2.05
4	CROSS	3878	5.31	2.77	8.49	2.71
4	SOUTH	3663	6.37	4.98	9.53	4.87
4	NORTH	3663	5.85	2.43	9.02	2.38
4	TOTAL SITE	3608	5.89	3.38	9.06	3.30
5	CENTER	3564	6.04	2.68	9.21	2.62
5	CROSS	2857	7.16	3.19	10.31	3.12
5	SOUTH	2574	7.93	4.79	11.25	5.38
5	NORTH	4356	6.82	3.22	9.97	3.15
5	TOTAL SITE	3409	6.87	3.76	10.05	3.67
TOTAL STAND		4000	6.49	3.25	9.65	3.18

TABLE B7

MEDIUM ASPEN DIAMETER MEASUREMENTS
FROM TRANSECTS OF SITES

SITE: 1

Center Transect (.0101 ha)	Tree Diameter (cm)								
0 to 6.1 m									
6.1 to 12.2 m	6.3	4.0							
12.2 to 18.3 m	2.0	8.0							
18.3 to 24.4 m	11.0	10.0	8.0						
24.4 to 30.5 m	12.0	4.5	10.0	9.0					
30.5 to 36.6 m	15.0	7.0	3.3	5.0	3.0	8.0	4.5		
36.6 to 42.6 m	4.0	11.0	11.0	10.0	11.5	4.5	5.5	6.5	8.3
42.6 m to 50.3 m	3.5	14.0	13.0	5.5	3.0				

Cross Transect (.0049 ha)

0 to 6.1 m	9.0	3.0	3.5	4.5	6.3	11.0	3.5	5.5	4.5
	3.0	3.0	3.0	8.5					
6.1 to 12.2 m	2.0	6.5	9.3	9.5	5.0	6.0	11.3	4.0	5.5
	5.0	3.0	7.0	7.5					
12.2 to 18.3 m	8.0	4.0	10.5	8.0	8.5	6.0			
18.3 to 24.4 m	7.5	4.0	2.5	4.0	6.0	7.5			

South Transect (.1010 ha)

0 to 6.1 m	3.0	7.5	4.5	3.0	3.5	5.5			
6.1 to 12.2 m	7.0	3.0	4.0	3.5	3.0				
12.2 to 18.3 m	3.0	6.5							
18.3 to 24.4 m	7.0	6.0	2.0	2.0					
24.4 to 30.5 m	8.5	2.0	7.3	5.5	2.5	4.0			
30.5 to 36.6 m	5.0	5.5	12.8						
36.6 to 42.6 m	4.0	5.0	4.5	11.3	4.0	3.5	3.0	8.8	4.0
42.6 m to 50.3 m	3.0	3.0	9.8	22.0	5.0	7.0	8.5	5.0	3.5

North Transect (.0101 ha)

0 to 6.1 m									
6.1 to 12.2 m	5.0	3.0	3.0	5.0	6.0	6.0	3.0	3.0	6.0
12.2 to 18.3 m	2.0	2.0	3.0	5.5	4.0	8.0	10.0	5.0	7.0
	12.0								
18.3 to 24.4 m	5.0	5.0	11.0	10.0	9.0	8.0			
24.4 to 30.5 m	5.0	6.0	10.0	8.0					
30.5 to 36.6 m	4.0	5.0	5.0	8.0	5.0	8.5	8.0	3.0	
36.6 to 42.6 m	5.0	7.5	5.5	10.0	9.0	8.0	6.0	6.5	6.0
	5.0								
42.6 m to 50.3 m	5.0	11.0	5.0	7.0	10.5	14.5	6.0		

TABLE B7 (continued)

MEDIUM ASPEN DIAMETER MEASUREMENTS
FROM TRANSECTS OF SITES

SITE: 2

Center Transect (.0101 ha)	Tree Diameter (cm)								
0 to 6.1 m	8.5	9.5	4.0	6.0	8.0	8.3	9.0		
6.1 to 12.2 m	4.5	4.0	9.0	5.8	8.3	3.3	7.0	5.5	4.5
12.2 to 18.3 m	4.0	2.5	2.0						
18.3 to 24.4 m	4.0	2.0	3.5	3.5	3.0	3.5	3.0		
24.4 to 30.5 m									
30.5 to 36.6 m	7.0	3.0	7.0	5.0	4.0	9.0	8.5		
36.6 to 42.6 m	5.5	4.0	19.0						
42.6 m to 50.3 m	5.0	4.0	3.0	4.0	4.0				

Cross Transect (.0049 ha)

0 to 6.1 m	10.3	4.0	8.5	4.0	4.5	4.0
6.1 to 12.2 m	6.0	3.0	2.5	4.5	10.5	6.0
12.2 to 18.3 m	4.0					
18.3 to 24.4 m	3.0	6.0	6.5	6.0		

South Transect (.0101 ha)

0 to 6.1 m	3.5	6.3	7.0	11.8				
6.1 to 12.2 m	2.6	3.0	9.6	3.3				
12.2 to 18.3 m	5.5	2.5	4.0	7.0	6.0			
18.3 to 24.4 m	5.3	6.8	6.6					
24.4 to 30.5 m	2.5	8.8	10.0	6.5				
30.5 to 36.6 m	10.6	10.8	4.6	13.0	8.8	10.6		
36.6 to 42.6 m	5.6	8.5	6.3	3.0	10.3	9.0	5.0	9.6
42.6 m to 50.3 m	7.8	4.0	4.0					

North Transect (.0101 ha)

0 to 6.1 m	7.5	5.0	5.5	5.0	4.5
6.1 to 12.2 m	4.0				
12.2 to 18.3 m	4.6	2.0	3.0	6.0	
18.3 to 24.4 m	3.6				
24.4 to 30.5 m	12.9	9.0	8.0		
30.5 to 36.6 m	3.6	10.3			
36.6 to 42.6 m	3.0				
42.6 m to 50.3 m	3.8	6.0			

TABLE B7 (continued)

MEDIUM ASPEN DIAMETER MEASUREMENTS
FROM TRANSECTS OF SITES

SITE: 3

Center Transect (.0101 ha)	Tree Diameter (cm)								
0 to 6.1 m	4.0	4.0	5.0	4.5	5.0				
6.1 to 12.2 m	7.5	6.0	4.0	6.5	9.3				
12.2 to 18.3 m	14.0	11.5	8.0	6.0	13.3	8.5			
18.3 to 24.4 m	12.0	10.0							
24.4 to 30.5 m	7.5	5.5	11.0	7.0	8.0				
30.5 to 36.6 m	6.5	5.0	10.5	7.5	11.0	4.0	6.5	5.5	
36.6 to 42.6 m	8.0								
42.6 m to 50.3 m	8.0	9.5	8.5	8.0					

Cross Transect (.0049 ha)									
0 to 6.1 m	7.0	5.3							
6.1 to 12.2 m	7.0	7.0	5.3	11.0	11.8	4.0	8.3		
12.2 to 18.3 m	5.0	5.0	4.0	11.8	16.5	9.3	10.8	7.0	
18.3 24.4 m	5.8	4.5	11.0	9.0					

South Transect (.0	6.0	4.5	8.0	6.0	9.0	11.0	6.5	4.5	5.5
0 to 6.1 m	6.0	11.0	5.0	10.0	6.5				
6.1 to 12.2 m	6.0	11.0	6.5	4.0	6.0	4.5	8.5	7.5	
12.2 to 18.3 m	5.5	8.0	6.5	6.0	10.3	6.0	5.5	11.5	
18.3 to 24.4 m	12.0								
24.4 to 30.5 m	6.0	5.5	7.0	14.0					
30.5 to 36.6 m	11.0	9.0	3.0	4.5	5.3	4.3	9.0	5.0	10.5
36.6 to 42.6 m	6.0	7.0	3.5	8.5					
42.6 m to 50.3 m	5.5	9.5	7.0	5.5	5.0	6.0	7.0	8.0	

North Transect (.0101 ha)									
0 to 6.1 m	6.5	8.5	9.8	3.5	7.5	6.5	7.5		
6.1 to 12.2 m	4.0	4.0	12.0	6.0	5.5	9.0	8.5	14.5	3.0
	3.0	5.5	3.5	6.5					
12.2 to 18.3 m	12.5	11.8	14.8	12.5	9.8	12.0			
18.3 to 24.4 m	4.5	13.5							
24.4 to 30.5 m	3.5	5.5	4.0	6.0	6.0	10.5	7.0	9.0	3.5
	5.0								
30.5 to 36.6 m	7.6	6.0	4.5	6.5	4.0	5.0			
36.6 to 42.6 m	3.0	7.5	3.0	6.0					
42.6 m to 50.3 m	6.0	4.5	8.0	6.0	9.0	11.0	6.5	4.5	5.5
	6.0	7.0	4.0						

TABLE B7 (continued)

MEDIUM ASPEN DIAMETER MEASUREMENTS
FROM TRANSECTS OF SITES

SITE: 4

Center Transect (.0101 ha)	Tree Diameter (cm)								
0 to 6.1 m									
6.1 to 12.2 m									
12.2 to 18.3 m	4.5	3.3							
18.3 to 24.4 m	4.3	4.0	3.5	5.8	4.6	8.5	9.0		
24.4 to 30.5 m	5.8	7.0	4.0	6.3	3.5	6.0	3.5	8.5	4.3
	5.5	3.0							
30.5 to 36.6 m	6.0	13.3	6.6	4.5					
36.6 to 42.6 m	6.3	6.0	3.8						
42.6 m to 50.3 m	5.0	9.5	5.0	6.5	6.6	5.5	5.8		

Cross Transect (.0049 ha)

0 to 6.1 m	4.3	4.8	8.0	4.5	9.5	2.8	2.8	10.0
6.1 to 12.2 m	2.5	3.0	2.8					
12.2 to 18.3 m	10.5	2.6	4.3	4.0	6.8	4.8	9.8	
18.3 to 24.4 m	3.0							

South Transect (.0101 ha)

0 to 6.1 m	7.0	6.6	4.5						
6.1 to 12.2 m	6.0								
12.2 to 18.3 m	3.0								
18.3 to 24.4 m	3.8	3.5	5.5	6.3	6.0				
24.4 to 30.5 m	8.0	5.8	9.3						
30.5 to 36.6 m	2.8	2.3	7.3	3.0	10.0	8.3	6.3	4.5	8.0
	3.0								
36.6 to 42.6 m	5.0	6.0	3.3	4.6	4.0	4.3	3.8	2.8	2.3
	6.5								
42.6 m to 50.3 m	6.0	5.3	25.1	26.0					

North Transect (.0101 ha)

0 to 6.1 m	4.8	3.3	2.8						
6.1 to 12.2 m									
12.2 to 18.3 m	6.8	4.8	4.8	5.3					
18.3 to 24.4 m	2.3	4.0	5.2	11.5	4.8	3.8			
24.4 to 30.5 m	11.0	3.3	8.3	8.0					
30.5 to 36.6 m	9.3	4.0	3.6	5.2	9.0	3.0	6.0	7.0	5.3
	7.0								
36.6 to 42.6 m	4.3								
42.6 m to 50.3 m	5.3	5.2	5.0	10.5	9.0	9.3	4.3	6.6	2.8

TABLE B7 (concluded)

MEDIUM ASPEN DIAMETER MEASUREMENTS
FROM TRANSECTS OF SITES

SITE: 5

Center Transect (.0101 ha)	Tree Diameter (cm)								
0 to 6.1 m	3.0								
6.1 to 12.2 m	3.3	5.8	5.2	5.8	5.3	6.0	13.2	6.2	
12.2 to 18.3 m	11.0	3.0	2.2	5.1	5.0	12.0			
18.3 to 24.4 m									
24.4 to 30.5 m	3.8	3.8	3.2	6.0					
30.5 to 36.6 m	10.0	9.5	5.0	5.8	5.5	5.3			
36.6 to 42.6 m	2.5	5.5	4.0	4.2	3.8	9.5			
42.6 m to 50.3 m	8.0	9.0	8.0	6.0	7.0				
Cross Transect (.0049 ha)									
0 to 6.1 m	5.0	11.5	9.0	5.5	8.5				
6.2 to 12.2 m	4.0	8.5	8.0						
12.2 to 18.3 m	4.0	2.3	5.5						
18.3 to 24.4 m	5.0	14.5	9.0						
South Transect (.0101 ha)									
0 to 6.1 m	6.1	22.8							
6.2 to 12.2 m	15.0	11.0	10.5	8.3					
12.2 to 18.3 m	8.2	13.5							
18.3 to 24.4 m	3.8	3.5	11.5	8.5	3.0	3.0	4.2		
24.4 to 30.5 m	4.8	3.8	5.0	2.8	4.5				
30.5 to 36.6 m	3.5	6.0	3.0						
36.6 to 42.6 m	4.0								
42.6 m to 50.3 m	20.0	16.0							
North Transect (.0101 ha)									
0 to 6.1 m	14.0	5.2	4.8	3.0	2.5				
6.2 to 12.2 m	6.5								
12.2 to 18.3 m	5.0	4.3							
18.3 to 24.4 m	10.3	7.0	4.0	5.0	7.2				
24.4 to 30.5 m	3.0	4.5							
30.5 to 36.6 m	11.0	6.5	4.2	7.0	4.5	15.0	6.5	5.2	9.8
	4.2	4.0	12.0						
36.6 to 42.6 m	3.5	6.0	3.2	4.5	10.8	6.0	10.0	4.5	8.0
42.6 m to 50.3 m	4.5	4.0	14.2	8.2	11.0	9.8	6.5	8.5	

TABLE B8

SUMMARY OF TREE AND CANOPY HEIGHT MEASUREMENTS FOR DENSE ASPEN STANDS

Diameter (cm)	Total Height (m)	Height of Lowest Living Branch (m)
17.0	21.3	10.9
13.5	20.2	14.2
17.5	23.3	15.3
18.4	21.9	10.9
19.3	25.7	11.5
12.1	19.7	12.0
17.3	19.5	10.7
11.2	14.8	6.3
10.8	15.6	8.5
10.6	11.5	3.8
13.6	18.0	11.5
15.5	19.7	11.3
15.6	21.9	11.5
17.4	20.2	10.9
14.0	19.1	8.7
12.4	15.9	8.2
11.6	16.4	8.7
15.4	17.5	7.1
15.1	15.9	6.0
14.2	17.5	6.0
10.4	14.8	8.2
22.7	18.0	6.0
29.0	22.7	6.3
16.0	20.8	9.3
11.4	13.7	7.7
9.7	13.7	5.5
16.5	21.3	9.3
15.5	21.9	10.9
17.0	20.2	9.3
21.7	19.1	7.7
15.0	16.0	
14.4	15.5	
9.2	11.9	
15.9	15.5	
17.4	15.1	
23.0	16.5	
9.9	12.3	
12.2	14.2	
10.3	12.3	
13.1	14.6	
13.3	15.5	

TABLE B8 (concluded)

SUMMARY OF TREE AND CANOPY HEIGHT MEASUREMENTS FOR DENSE ASPEN STANDS

Diameter (cm)	Total Height (m)	Height of Lowest Living Branch (m)
11.0	12.3	
13.1	17.4	
10.0	12.8	
16.0	12.8	
17.5	17.4	
16.2	16.9	
9.5	12.3	
31.8	15.5	
15.5	16.5	
12.0	15.1	
13.6	16.5	
16.5	18.3	
21.5	18.7	
13.6	13.7	
21.8	18.7	
10.5	8.2	
19.9	17.8	
14.6	18.3	
12.5	13.7	
13.0	14.2	
13.0	15.5	
21.0	18.3	
16.3	14.2	
21.8	18.3	
14.5	14.2	
16.7	18.0	
13.0	21.9	
10.8	13.3	
19.3	16.5	
18.9	16.5	
10.5	16.0	
11.5	16.0	
16.8	19.7	

TABLE B9

SUMMARY OF TRANSECT MEASUREMENTS FOR DENSE ASPEN STANDS

Site 1

Transect	Number of Trees	Trees per Hectare	Average Diameter (cm)	Std Dev	Average Height (m)	Std Dev
0 Degrees	12	1200	9.8	4.92	14.0	2.76
45 Degrees	11	1100	19.8	9.80	19.6	5.49
135 Degrees	17	1700	10.9	5.79	14.6	3.24
180 Degrees	14	1400	12.9	5.04	15.7	2.82
225 Degrees	8	800	14.8	10.13	16.8	5.76
270 Degrees	17	1700	9.1	2.92	13.6	1.64
315 Degrees	18	1800	10.6	6.88	14.5	3.85
Subtotal	97	1386	12.0	7.24	15.2	4.05
Reflector	77	1838	13.8	6.57	16.2	3.67
Total Stand	174	1555	12.8	7.01	15.6	4.00

Site 2

Transect	Number of Trees	Trees per Hectare	Average Diameter (cm)	Std Dev	Average Height (m)	Std Dev
0 Degrees	21	2100	12.6	2.63	15.5	1.47
45 Degrees	12	1200	13.1	8.47	15.8	4.75
135 Degrees	7	700	13.6	6.53	16.1	3.66
180 Degrees	7	700	14.5	9.60	16.6	5.37
225 Degrees	13	1300	12.2	3.39	15.3	1.90
270 Degrees	14	1400	11.6	3.00	15.0	1.68
315 Degrees	15	1500	12.0	3.02	15.2	1.69
Subtotal	89	1271	12.6	5.21	15.5	2.92
Reflector	57	1360	10.9	4.80	14.6	2.69
Total Stand	146	1305	11.9	5.12	15.2	2.87

TABLE B9 (continued)

SUMMARY OF TRANSECT MEASUREMENTS FOR DENSE ASPEN STANDS

Site 3

Transect	Number of Trees	Trees per Hectare	Average Diameter (cm)	Std Dev	Average Height (m)	Std Dev
0 Degrees	9	900	14.4	3.93	16.6	2.20
45 Degrees	15	1500	13.9	4.17	16.3	2.33
135 Degrees	12	1200	16.0	3.40	17.5	1.91
180 Degrees	13	1300	14.5	4.71	16.6	2.64
225 Degrees	11	1100	14.0	5.98	16.4	3.35
270 Degrees	15	1500	13.5	4.20	16.1	2.35
315 Degrees	18	1800	13.9	2.87	16.3	1.61
Subtotal	93	1329	14.3	4.26	16.5	2.38
Corner Reflector	91	1857	13.5	4.05	16.0	2.27
Total Stand	184	1644	13.9	4.17	16.3	2.34

Site 4

Transect	Number of Trees	Trees per Hectare	Average Diameter (cm)	Std Dev	Average Height (m)	Std Dev
0 Degrees	9	900	16.2	4.40	17.6	2.46
45 Degrees	19	1520	14.0	5.62	16.7	3.22
135 Degrees	16	1600	14.4	3.19	16.6	1.79
180 Degrees	10	1000	16.4	3.74	17.7	2.10
225 Degrees	11	1100	14.5	6.12	16.6	3.43
270 Degrees	3	300	20.3	8.46	19.9	4.74
315 Degrees	6	600	17.6	4.80	18.3	2.69
Subtotal	74	1021	15.3	5.23	17.2	2.92
Corner Reflector	98	2339	14.1	3.21	16.4	1.80
Total Stand	172	1503	14.6	4.24	16.7	2.37

TABLE B9 (concluded)

SUMMARY OF TRANSECT MEASUREMENTS FOR DENSE ASPEN STANDS

Site 5 - Aspen Trees Only

	Number of Trees	Trees per Hectare	Average Diameter (cm)	Std Dev	Average Height (m)	Std Dev
0 Degrees	15	1500	14.6	10.59	16.7	5.93
45 Degrees	14	1400	10.9	7.67	14.6	4.30
105 to 160 Degrees	6	343	9.7	1.73	13.9	.97
160 to 205 Degrees	8	509	9.1	2.22	13.6	1.24
205 to 250 Degrees	10	637	12.3	5.28	15.4	2.95
270 Degrees	20	2000	13.8	9.69	15.8	4.82
315 Degrees	22	2200	14.9	7.01	16.9	3.93
Subtotal	96	1571	12.9	8.07	15.7	4.42
Corner Reflector	88	2100	12.8	8.20	15.8	4.74
Total Stand	182	1767	13.0	8.28	15.7	4.57

Site 5 - All Trees

	Number of Trees	Trees per Hectare	Average Diameter (cm)	Std Dev
0 Degrees	20	2000	13.3	9.62
45 Degrees	26	2600	10.2	6.87
105 to 160 Degrees	14	802	15.1	8.87
205 to 250 Degrees	13	828	14.0	6.54
270 Degrees	23	2300	13.3	9.20
315 Degrees	27	2700	13.5	7.07
Subtotal	141	2308	13.0	8.14
90 Degrees	98	2340	13.0	9.20
Total	236	2291	13.2	8.74

TABLE B10

SUMMARY OF HEADING, DISTANCE AND DIAMETER MEASUREMENTS FOR AREA IN FRONT OF CORNER REFLECTORS IN THE DENSE ASPEN STAND

Site: 1

Heading (degrees)	Distance (m)	Diameter (cm)	Species
75	5.7	16.0	aspen
75	7.8	5.0	cherry
74	9.2	14.8	aspen
76	10.9	15.2	aspen
88	15.2	7.6	aspen
88	17.3	17.5	aspen
83	18.4	7.5	aspen
87	19.6	14.5	aspen
87	21.0	8.2	aspen
89	21.6	7.0	aspen
89	22.3	7.5	aspen
90	24.6	33.2	aspen
80	22.5	11.0	aspen
81	23.5	8.7	aspen
77	28.4	33.2	aspen
80	28.6	16.4	aspen
81	28.7	11.3	aspen
83	28.6	7.0	aspen
85	28.7	13.0	aspen
82	28.2	11.0	aspen
81	29.4	13.2	aspen
82	29.5	11.0	aspen
80	31.5	23.2	aspen
78	33.0	18.7	aspen
77	35.0	18.3	aspen
80	35.0	9.1	aspen
83	34.8	14.5	aspen
88	36.6	13.5	aspen
87	38.5	14.5	aspen
85	40.0	13.6	aspen
83	38.0	13.0	aspen
76	39.0	15.5	aspen
77	40.0	10.5	aspen
91	4.1	6.0	aspen
105	6.4	12.5	aspen
98	7.3	6.8	cherry
103	9.5	13.0	aspen
94	10.3	7.2	aspen
102	14.6	14.0	aspen

TABLE B10 (continued)

SUMMARY OF HEADING, DISTANCE AND DIAMETER MEASUREMENTS FOR AREA IN FRONT OF CORNER REFLECTORS IN THE DENSE ASPEN STAND

Site: 1

Heading (degrees)	Distance (m)	Diameter (cm)	Species
100	15.8	13.0	aspen
103	16.4	10.5	aspen
91	17.0	31.5	aspen
96	19.7	7.0	aspen
95	20.0	13.0	aspen
103	18.1	9.0	aspen
104	19.3	8.5	aspen
96	20.5	11.3	aspen
94	23.0	10.0	aspen
95	23.5	10.6	aspen
98	23.5	7.2	aspen
100	23.5	31.4	aspen
91	25.9	8.5	aspen
91	27.6	18.0	aspen
93	27.6	8.7	aspen
95	27.6	9.2	aspen
97	29.0	14.3	aspen
99	27.6	15.2	aspen
102	29.5	36.9	aspen
103	30.5	6.0	aspen
100	33.5	12.0	aspen
91	33.0	29.5	aspen
95	31.0	13.3	aspen
95	33.0	19.5	aspen
97	32.0	10.5	aspen
97	31.0	11.3	aspen
97	33.0	10.0	aspen
92	35.5	10.5	aspen
91	36.7	8.0	aspen
93	37.4	17.0	aspen
92	40.0	17.5	aspen
95	38.0	16.5	aspen
97	39.0	13.3	aspen
96	36.5	10.8	aspen
97	36.5	18.0	aspen
97	35.5	16.0	aspen
97	35.0	12.5	aspen
103	36.0	8.5	aspen

TABLE B10 (continued)

SUMMARY OF HEADING, DISTANCE AND DIAMETER MEASUREMENTS FOR AREA IN FRONT OF CORNER REFLECTORS IN THE DENSE ASPEN STAND

Site: 1

103	37.4	16.5	aspen
104	39.7	11.0	aspen

TABLE B10 (continued)

SUMMARY OF HEADING, DISTANCE AND DIAMETER
MEASUREMENTS FOR AREA IN FRONT OF CORNER
REFLECTORS IN THE DENSE ASPEN STAND

Site: 2

Heading (degrees)	Distance (m)	Diameter (cm)	Species
77	8.0	21.0	aspen
75	8.8	18.0	aspen
89	10.0	10.3	aspen
85	10.9	9.5	aspen
85	11.7	13.8	aspen
78	13.0	6.2	aspen
78	13.6	16.5	aspen
75	13.5	8.3	cherry
75	14.2	5.5	cherry
77	16.5	11.5	aspen
90	18.0	16.5	aspen
85	20.0	10.3	aspen
84	20.0	10.5	aspen
85	22.3	34.5	oak (20 m)
83	22.3	42.0	oak (20 m)
85	24.1	3.0	maple
90	25.2	9.8	oak
85	26.3	3.8	aspen
84	26.3	6.2	aspen
89	29.[illegible]	10.0	aspen
88	29.7	7.2	aspen
85	29.2	9.7	aspen
76	29.0	10.5	aspen
85	31.0	23.0	aspen
81	33.0	7.0	aspen
82	33.2	7.2	aspen
82	35.0	10.0	aspen
80	36.0	4.0	aspen
90	33.8	9.2	aspen
90	34.6	17.5	aspen
90	38.1	12.3	aspen
85	40.0	17.0	aspen
81	40.0	8.2	aspen
97	4.6	5.3	aspen
105	4.6	10.8	aspen
92	8.0	8.0	aspen
97	15.0	14.3	aspen

TABLE B10 (continued)

SUMMARY OF HEADING, DISTANCE AND DIAMETER
MEASUREMENTS FOR AREA IN FRONT OF CORNER
REFLECTORS IN THE DENSE ASPEN STAND

Site: 2

Heading (degrees)	Distance (m)	Diameter (cm)	Species
100	13.8	10.3	aspen
104	14.6	6.5	aspen
97	18.2	6.5	aspen
102	23.0	13.8	oak
95	25.5	28.7	aspen
92	30.5	9.5	aspen
97	31.5	9.2	aspen
100	33.8	28.0	oak
103	33.8	6.8	aspen
104	34.4	5.5	aspen
105	34.6	7.0	aspen
91	34.9	7.5	aspen
94	34.9	7.5	aspen
93	36.0	4.8	aspen
93	38.0	14.5	aspen
92	40.0	11.0	aspen
93	38.5	8.2	aspen
94	38.5	15.0	aspen
95	36.5	15.0	aspen
97	37.5	8.0	aspen
100	36.0	9.0	aspen
100	37.0	12.3	aspen
100	39.0	11.3	aspen
102	36.3	6.5	aspen
103	38.2	10.2	aspen
103	39.7	12.3	aspen
104	39.0	7.0	aspen
105	40.0	16.7	aspen

TABLE B10 (continued)

SUMMARY OF HEADING, DISTANCE AND DIAMETER
MEASUREMENTS FOR AREA IN FRONT OF CORNER
REFLECTORS IN THE DENSE ASPEN STAND

Site: 3

Heading (degrees)	Distance (m)	Diameter (cm)	Species
85	2.5	20.5	aspen
85	4.4	18.0	aspen
85	5.7	11.3	aspen
80	8.8	12.3	aspen
76	9.9	12.5	aspen
77	10.0	9.0	aspen
89	9.0	9.5	aspen
88	9.8	15.0	aspen
76	13.2	16.0	aspen
75	16.3	24.9	aspen
85	16.0	12.1	aspen
84	17.0	10.0	aspen
78	18.4	12.0	aspen
86	18.7	13.8	aspen
84	19.5	15.0	aspen
75	24.5	12.0	aspen
82	25.0	13.5	aspen
83	25.0	16.2	aspen
83	25.5	21.8	aspen
90	27.8	8.5	cherry
85	28.5	11.2	aspen
77	26.5	11.0	aspen
75	28.5	8.0	aspen
78	28.0	13.5	aspen
78	27.5	11.0	aspen
86	30.0	5.5	aspen
84	30.5	6.0	aspen
83	30.7	12.5	aspen
82	30.7	19.8	aspen
77	30.0	7.8	aspen
76	32.0	13.5	aspen
76	32.5	16.5	aspen
77	34.0	13.8	aspen
79	34.0	6.5	aspen
83	30.0	19.0	aspen
83	33.0	16.5	aspen
84	31.5	11.0	aspen
85	31.0	13.5	aspen
85	33.0	9.5	aspen

TABLE B10 (continued)

SUMMARY OF HEADING, DISTANCE AND DIAMETER MEASUREMENTS FOR AREA IN FRONT OF CORNER REFLECTORS IN THE DENSE ASPEN STAND

Site: 3

Heading (degrees)	Distance (m)	Diameter (cm)	Species
85	33.5	7.8	aspen
87	32.0	7.2	aspen
88	32.0	5.0	cherry
89	32.0	9.8	aspen
89	33.0	15.7	aspen
90	34.3	4.2	cherry
88	34.5	10.8	aspen
86	35.5	13.5	aspen
84	35.5	6.5	aspen
87	38.0	15.5	aspen
86	39.0	9.8	aspen
85	39.0	15.0	aspen
85	39.1	8.1	aspen
84	39.0	14.5	aspen
82	40.0	16.0	aspen
80	39.0	7.8	aspen
82	36.0	12.5	aspen
75	36.5	10.9	aspen
76	38.7	9.5	aspen
77	40.0	8.8	cherry
100	4.9	20.3	aspen
91	6.5	9.2	aspen
102	6.2	10.5	aspen
104	8.2	14.2	aspen
104	9.7	12.5	aspen
91	10.8	12.1	aspen
104	11.8	8.5	aspen
103	12.2	14.5	aspen
100	15.2	18.0	oak
97	17.2	9.7	aspen
91	18.8	16.0	aspen
93	18.7	20.0	aspen
90	20.0	20.5	aspen
91	21.8	18.0	aspen
90	23.4	14.0	aspen
103	23.5	19.0	aspen
102	25.0	18.3	aspen
100	24.5	19.8	aspen
100	25.7	8.0	cherry

TABLE B10 (continued)

SUMMARY OF HEADING, DISTANCE AND DIAMETER
MEASUREMENTS FOR AREA IN FRONT OF CORNER
REFLECTORS IN THE DENSE ASPEN STAND

Site: 3

Heading (degrees)	Distance (m)	Diameter (cm)	Species
102	26.5	17.8	aspen
102	27.5	17.5	aspen
91	26.0	14.2	aspen
90	28.0	14.2	aspen
93	28.2	16.5	aspen
98	29.5	11.2	aspen
104	29.4	18.0	aspen
104	30.6	5.2	oak
105	31.4	10.2	aspen
103	31.5	17.2	aspen
103	33.2	13.5	aspen
105	33.7	8.0	aspen
104	36.5	18.8	aspen
104	39.7	16.5	aspen
102	37.0	15.5	aspen
100	40.0	15.5	aspen
99	39.0	13.5	aspen
99	40.0	9.8	cherry
95	36.0	9.0	aspen
92	33.5	14.0	aspen
90	32.3	15.0	aspen

TABLE B10 (continued)

SUMMARY OF HEADING, DISTANCE AND DIAMETER MEASUREMENTS FOR AREA IN FRONT OF CORNER REFLECTORS IN THE DENSE ASPEN STAND

Site: 4

Heading (degrees)	Distance (m)	Diameter (cm)	Species
75	2.0	13.1	aspen
90	6.7	20.0	aspen
105	7.0	19.1	oak
100	9.7	13.8	aspen
105	11.0	15.3	aspen
100	14.0	20.8	aspen
100	11.5	10.0	aspen
90	11.0	18.3	aspen
87	10.5	7.4	aspen
86	10.5	7.8	cherry
75	9.7	13.0	aspen
80	14.0	5.5	cherry
86	12.5	9.5	aspen
86	13.5	9.1	aspen
105	16.5	20.9	aspen
90	16.5	18.0	aspen
85	16.5	16.5	aspen
78	17.0	19.5	aspen
76	17.8	15.4	aspen
80	18.5	15.3	aspen
81	18.2	11.8	aspen
73	17.8	17.8	aspen
85	18.0	12.0	aspen
90	19.0	10.2	aspen
100	19.0	11.0	aspen
100	22.0	12.8	aspen
95	22.0	16.6	aspen
95	22.5	12.6	aspen
78	20.5	15.6	aspen
78	20.6	15.4	aspen
78	22.0	12.0	aspen
80	22.2	11.0	aspen
83	22.5	8.0	aspen
97	23.5	14.7	aspen
100	23.5	11.7	aspen
101	23.5	14.3	aspen
105	23.5	11.2	aspen
87	25.0	16.8	aspen
87	26.5	16.7	aspen

TABLE B10 (continued)

SUMMARY OF HEADING, DISTANCE AND DIAMETER MEASUREMENTS FOR AREA IN FRONT OF CORNER REFLECTORS IN THE DENSE ASPEN STAND

Site: 4

Heading (degrees)	Distance (m)	Diameter (cm)	Species
85	26.0	17.1	aspen
78	24.5	17.8	aspen
77	25.0	10.2	aspen
77	26.5	8.9	aspen
77	27.5	13.7	oak
78	27.5	18.0	aspen
82	28.0	12.3	aspen
81	28.2	14.0	aspen
83	29.0	8.6	aspen
95	27.0	29.5	oak
95	28.8	21.0	oak
98	28.0	29.5	oak
99	33.0	14.3	aspen
97	33.5	11.1	aspen
92	33.5	12.1	aspen
90	33.5	17.4	aspen
88	32.8	12.8	aspen
86	33.5	9.4	aspen
84	34.0	8.0	aspen
86	32.0	10.6	aspen
80	32.0	17.8	aspen
79	32.0	12.9	aspen
75	33.3	13.3	aspen
76	33.6	15.0	aspen
77	33.5	8.5	cherry
78	33.0	9.0	cherry
81	35.0	16.1	aspen
81	34.0	21.8	aspen
82	34.0	15.1	aspen
83	35.0	11.3	aspen
84	34.8	11.6	aspen
84	33.8	15.0	aspen
87	35.0	15.6	aspen
90	36.0	16.6	aspen
90	35.5	15.0	aspen
91	35.5	9.8	aspen
92	35.5	10.1	aspen
95	35.0	14.7	aspen
104	36.5	21.2	aspen

TABLE B10 (continued)

SUMMARY OF HEADING, DISTANCE AND DIAMETER MEASUREMENTS FOR AREA IN FRONT OF CORNER REFLECTORS IN THE DENSE ASPEN STAND

Site: 4

Heading (degrees)	Distance (m)	Diameter (cm)	Species
103	36.5	15.6	aspen
100	38.0	22.5	oak
103	40.0	17.7	aspen
104	40.0	12.8	aspen
100	39.0	16.1	aspen
99	38.0	12.3	aspen
97	38.0	14.1	aspen
96	38.0	11.8	aspen
96	40.0	17.7	aspen
92	39.0	13.5	aspen
93	37.5	10.9	aspen
91	37.5	13.1	aspen
87	40.0	16.8	aspen
86	39.0	18.7	aspen
86	39.0	14.2	aspen
77	45.0	17.5	aspen
76	44.0	16.2	aspen
76	42.0	16.3	aspen
76	40.0	11.5	aspen
77	40.5	9.8	aspen
77	39.5	9.8	aspen
76	38.0	14.8	aspen
80	38.0	14.1	aspen
80	40.0	13.1	aspen
81	40.5	14.8	aspen
82	40.0	15.6	aspen
83	40.0	13.5	aspen
83	37.0	17.0	aspen
84	40.0	13.2	aspen
83	40.4	14.7	aspen

TABLE B10 (continued)

SUMMARY OF HEADING, DISTANCE AND DIAMETER MEASUREMENTS FOR AREA IN FRONT OF CORNER REFLECTORS IN THE DENSE ASPEN STAND

Site: 5

Heading (degrees)	Distance (m)	Diameter (cm)	Species
105	1.9	7.5	aspen
105	3.2	6.2	aspen
105	3.8	4.6	maple
90	4.6	26.0	oak
105	9.6	8.0	oak
100	10.0	23.8	aspen
95	10.6	7.8	aspen
94	10.8	60.0	aspen
80	10.5	7.7	aspen
75	10.0	6.6	aspen
75	12.6	10.9	aspen
95	12.8	6.7	aspen
95	15.0	9.0	aspen
80	15.0	19.9	aspen
80	17.0	9.7	aspen
90	17.0	9.3	aspen
85	17.3	7.4	maple
95	18.0	8.1	aspen
92	18.0	13.3	aspen
98	18.3	11.0	aspen
100	20.0	11.5	aspen
97	21.5	9.2	aspen
95	21.2	17.5	aspen
90	22.0	11.2	aspen
80	21.7	14.5	aspen
103	26.5	29.3	aspen
105	27.2	7.0	aspen
101	28.0	9.2	aspen
102	28.2	6.8	aspen
101	28.8	8.0	aspen
98	28.6	8.0	aspen
97	28.6	13.5	aspen
98	29.3	12.5	aspen
102	30.0	12.0	aspen
97	30.6	16.8	aspen
93	30.6	12.6	aspen
90	30.6	12.2	aspen
88	30.4	16.2	aspen
89	30.9	6.3	oak

TABLE B10 (continued)

SUMMARY OF HEADING, DISTANCE AND DIAMETER
MEASUREMENTS FOR AREA IN FRONT OF CORNER
REFLECTORS IN THE DENSE ASPEN STAND

Site: 5

Heading (degrees)	Distance (m)	Diameter (cm)	Species
75	25.6	13.2	aspen
77	28.3	5.1	aspen
78	31.0	12.5	aspen
80	31.0	12.7	aspen
85	31.0	16.5	aspen
86	31.5	10.1	aspen
90	31.0	7.7	aspen
90	32.2	15.7	aspen
98	31.0	16.8	aspen
102	30.0	12.1	aspen
104	33.2	14.5	aspen
102	33.2	9.2	aspen
101	33.5	16.8	aspen
98	34.1	19.6	aspen
96	34.3	8.7	aspen
90	33.1	14.0	aspen
90	34.1	3.6	maple
90	34.1	8.8	maple
78	37.5	8.6	aspen
77	37.0	15.3	aspen
76	37.3	16.7	aspen
75	36.0	8.5	aspen
80	34.0	12.5	aspen
81	33.0	15.0	aspen
82	31.0	12.7	aspen
82	37.5	11.3	aspen
90	36.0	9.8	aspen
102	34.8	12.9	aspen
102	35.0	14.9	aspen
104	34.8	9.0	aspen
104	35.5	15.7	aspen
105	36.3	6.9	maple
104	37.2	9.2	aspen
102	39.7	10.6	aspen
98	40.0	12.5	aspen
97	40.0	13.2	aspen
95	39.0	7.3	aspen
95	39.5	9.4	aspen
95	39.0	8.0	aspen

TABLE B10 (continued)

SUMMARY OF HEADING, DISTANCE AND DIAMETER MEASUREMENTS FOR AREA IN FRONT OF CORNER REFLECTORS IN THE DENSE ASPEN STAND

Site: 5

Heading (degrees)	Distance (m)	Diameter (cm)	Species
94	41.0	12.1	aspen
93	40.5	11.3	aspen
90	40.0	7.6	aspen
77	40.7	18.6	aspen
78	42.0	8.3	aspen
76	44.0	5.6	aspen
76	48.0	14.8	aspen
85	45.0	55.9	oak
90	48.0	62.5	aspen
101	41.7	9.3	aspen
100	42.7	14.5	aspen
104	42.0	12.2	aspen
103	45.2	14.5	aspen
101	47.5	15.0	aspen
100	48.0	17.0	aspen
101	49.0	16.5	aspen
104	50.0	25.7	maple
105	3.3	7.0	aspen
110	5.0	7.5	aspen
115	4.8	12.2	aspen
105	6.0	7.2	aspen
120	9.0	10.7	cherry
135	12.0	11.5	oak
120	12.0	34.0	oak
105	15.0	6.1	aspen
135	14.0	8.2	aspen
137	16.2	11.0	aspen
140	18.6	9.6	aspen
140	19.6	11.5	birch
150	19.5	34.3	maple
141	11.8	21.3	maple
145	13.0	16.6	oak
141	18.0	8.0	oak
165	4.5	7.9	maple
165	5.8	21.6	oak
200	5.6	9.0	aspen
200	2.6	8.1	aspen
180	4.7	23.5	oak
195	7.5	9.3	cherry

TABLE B10 (concluded)

SUMMARY OF HEADING, DISTANCE AND DIAMETER MEASUREMENTS FOR AREA IN FRONT OF CORNER REFLECTORS IN THE DENSE ASPEN STAND

Site: 5

Heading (degrees)	Distance (m)	Diameter (cm)	Species
180	8.7	27.6	oak
200	8.7	8.7	aspen
200	10.5	14.5	aspen
195	12.0	7.4	aspen
190	11.8	9.6	aspen
185	12.0	9.4	cherry
180	12.2	8.9	aspen
170	12.5	13.3	oak
168	13.0	29.2	oak
197	14.9	6.7	aspen
200	19.5	25.6	oak
248	15.8	21.5	aspen
250	13.0	9.7	aspen
245	12.7	15.0	aspen
225	11.0	22.0	aspen
240	10.4	10.2	black cherry
250	8.8	26.0	oak
248	6.0	9.0	aspen
230	3.7	6.2	aspen
210	7.5	11.5	aspen
220	8.0	10.5	aspen
215	12.0	10.2	aspen
220	11.5	6.9	aspen
220	15.0	23.4	oak

TABLE B11

SUMMARY OF TREE DIAMETERS (cm) FROM DENSE ASPEN SITE TRANSECTS
(distances are meters from target)

Site: 1

0 Degree Heading						
0 to 5 m	16.5					
5 to 10 m	9.3	4.0	4.0	9.5	4.0	
10 to 15 m	6.0	8.5	19.2			
15 to 20 m	13.2	8.5	15.0			
45 Degree Heading						
5 to 10 m	23.1	33.3	26.9	8.0	9.5	7.5 (oak)
10 to 15 m	14.0	27.5	37.0	15.5		
15 to 20 m	14.0					
20 to 25 m	8.5	14.0 (maple)				
135 Degree Heading						
5 to 10 m	12.5	10.5	5.0	9.7	8.5	10.0
10 to 15 m	5.5	6.0	30.7	6.0	5.0 (cherry)	
15 to 20 m	11.0	12.0	12.5	5.5		
20 to 25 m	14.0	12.5	14.0			
180 Degree Heading						
0 to 5 m	16.5	23.0	9.3			
5 to 10 m	13.0	20.0	7.0			
10 to 15 m	7.5	9.0	13.3	8.6	6.3	17.5
15 to 20 m	12.5	16.8				
225 Degree Heading						
5 to 10 m	8.0	10.0 (b.cherry)				
10 to 15 m	33.4	30.1				
15 to 20 m	13.2	7.0	11.3			
20 to 25 m	5.0	10.0				
270 Degree Heading						
0 to 5 m	17.0	7.5	10.8	4.2 (oak)		
5 to 10 m	12.0	10.0	12.5			
10 to 15 m	6.0	5.0	11.5	6.5	7.0	
15 to 20 m	8.5	9.7	7.0	8.5	8.1	6.5
315 Degree Heading						
5 to 10 m	5.2	15.3	9.2	6.0	9.5	5.5 (oak)
10 to 15 m	8.0	8.5	29.5	8.2	5.8 (b.cherry)	
15 to 20 m	5.8	6.5	10.0	10.0	12.5	4.2 (b.cherry)
20 to 25 m	7.0	6.0	6.0	28.0		

TABLE B11 (continued)

SUMMARY OF TREE DIAMETERS (cm) FROM DENSE ASPEN SITE TRANSECTS
(distances are meters from target)

Site: 2

0 Degree Heading
0 to 5 m 15.2 15.7 11.0 15.0 8.2 3.0 (oak)
5 to 10 m 7.2 15.5 12.5 10.6 15.8
10 to 15 m 9.8 11.2 14.0 11.0 12.5 11.2 13.3
15 to 20 m 13.8 15.8 9.0 15.5 9.7 (oak) 7.6 (oak)

45 Degree Heading
5 to 10 m 8.0 12.5 15.0
10 to 15 m 13.5 38.8 11.5 4.6
15 to 20 m 5.0 13.3 7.6 13.5
20 to 25 m 13.5 12.0 (cherry) 10.5 (cherry)

135 Degree Heading
5 to 10 m 11.8
10 to 15 m 7.0 10.2 26.7 9.8
15 to 20 m 10.0 4.3 (maple)
20 to 25 m 20.0 8.8 (cherry)

180 Degree Heading
5 to 10 m 9.3
10 to 15 m 7.0 6.0 32.0 7.0 14.3
15 to 20 m 25.8
20 to 25 m no trees

225 Degree Heading
5 to 10 m 15.3 7.0 8.5 15.7 10.0 9.0 14.5
10 to 15 m 7.0
15 to 20 m 17.7 13.3 14.3
20 to 25 m 12.5 14.0 10.0 (cherry) 7.0 (cherry)

270 Degree Heading
0 to 5 m 9.2 6.2 8.2 17.6 16.0
5 to 10 m 11.7 14.8 10.5 5.2 (cherry) 7.0 (cherry)
17.2 (oak) 8.5 (oak)
10 to 15 m 12.7 12.0 12.5 7.5 (cherry)
15 to 20 m 10.3 8.8 12.5 3.0 (cherry) 6.5 (cherry)

315 Degree Heading
5 to 10 m 15.7 13.3 10.5 13.5
10 to 15 m 13.7 8.5 13.0 7.0 12.0 3.0 (cherry)
15 to 20 m 18.5 6.5 13.0 12.5 3.5 (cherry)
20 to 25 m 10.5 12.0

TABLE B11 (continued)

SUMMARY OF TREE DIAMETERS (cm) FROM DENSE ASPEN SITE TRANSECTS
(distances are meters from target)

Site: 3

0 Degree Heading								
0 to 5 m	20.5	6.2 (oak)		4.2 (maple)				
5 to 10 m	12.5	14.0	20.5					
10 to 15 m	9.0	15.0						
15 to 20 m	16.5	11.0	10.5					
45 Degree Heading								
5 to 10 m	21.8	12.3	15.5	12.0				
10 to 15 m	18.5	15.8						
15 to 20 m	7.2	6.5 (oak)						
20 to 25 m	8.5	12.5	13.3	16.5	17.0	6.5	18.0	13.5
135 Degree Heading								
5 to 10 m	no trees							
10 to 15 m	17.2	11.8	14.5	17.0				
15 to 20 m	14.0	21.6	12.0					
20 to 25 m	18.5	16.0	19.8	19.5	10.3			
180 Degree Heading								
0 to 5 m	22.7	9.5	15.5	3.5 (oak)				
5 to 10 m	22.0	15.8	12.0	3.5	2.5 (cherry)			
10 to 15 m	no trees							
15 to 20 m	15.0	15.5	13.0	15.0	16.0	12.5		
225 Degree Heading								
5 to 10 m	15.0	11.0						
10 to 15 m	30.4	32.2 (oak)						
15 to 20 m	9.0	9.0	6.0 (maple)					
20 to 25 m	12.8	9.0	17.8	16.8	10.0	13.5		
270 Degree Heading								
0 to 5 m	22.5	9.5						
5 to 10 m	17.0	18.0	16.5	8.5	9.7			
10 to 15 m	12.5	18.0	8.0	15.5	11.0	7.0 (birch)		
15 to 20 m	15.0	9.0	12.0					
315 Degree Heading								
5 to 10 m	11.8	15.7	13.2					
10 to 15 m	10.5	12.5	10.5	15.5	15.2	4.8 (cherry)		
	4.2 (cherry)			4.5 (cherry)				
15 to 20 m	9.0	17.5	13.8	6.2 (oak)				
20 to 25 m	17.2	15.5	9.5	18.5	16.3	11.2	16.5	

TABLE B11 (continued)

SUMMARY OF TREE DIAMETERS (cm) FROM DENSE ASPEN SITE TRANSECTS
(distances are meters from target)

Site: 4

0 Degree Heading
0 to 5 m 13.1 22.4 10.8 18.0 14.2 (oak) 13.2 (maple)
5 to 10 m no trees
10 to 15 m 17.0 21.3 4.5 (cherry)
15 to 20 m 10.1 12.7 20.4

45 Degree Heading
0 to 5 m 18.2 17.8 10.8 21.8 13.5 7.2 (cherry)
5 to 10 m 10.8 19.8 10.5
10 to 15 m 10.4 30.6 8.6 7.8 9.0 13.4
15 to 20 m 12.5 17.7 3.8 (cherry) 2.9 (cherry)
20 to 25 m 10.9 12.8 8.4

135 Degree Heading
5 to 10 m 12.6 15.6 20.5 15.0
10 to 15 m 12.5 11.8 10.2 14.5
15 to 20 m 9.4 10.2 15.5 19.8
20 to 25 m 18.1 16.3 13.1 15.4

180 Degree Heading
0 to 5 m 18.8
5 to 10 m 10.8 20.9 10.3 18.8 12.6 20.6 15.5
10 to 15 m 19.0 16.9
15 to 20 m no trees

225 Degree Heading
5 to 10 m 32.0 10.7
10 to 15 m 17.6 13.4 17.6 11.0 (cherry)
15 to 20 m 12.0 10.4 12.9 11.8
20 to 25 m 12.6 8.6

270 Degree Heading
0 to 5 m 12.8 (maple)
5 to 10 m 12.2 32.0
10 to 15 m no trees
15 to 20 m 16.8

315 Degree Heading
5 to 10 m 24.9 23.0 12.8 (oak) 17.1 (cherry)
10 to 15 m 33.7 (oak) 7.8 (cherry) 7.5 (cherry)
15 to 20 m no trees
20 to 25 m 14.6 17.0 11.8 14.0

TABLE B11 (concluded)

SUMMARY OF TREE DIAMETERS (cm) FROM DENSE ASPEN SITE TRANSECTS
(distances are meters from target)

Site: 5

0 Degree Heading

0 to 5 m	36.3 6.6 8.3 9.5 7.4
5 to 10 m	33.5 9.7 9.9 11.7 6.5 (cherry)
10 to 15 m	11.7 7.1 5.6 16.5 (oak)
15 to 20 m	11.3 14.0 36.1 9.6 (birch) 8.7 (birch)

45 Degree Heading

5 to 10 m	16.9 7.1 5.5 7.7 5.0 (oak) 26.3 (birch)
10 to 15 m	7.3 5.0 7.2 10.3 8.7 5.0 (oak)
15 to 20 m	36.2 14.5 5.5 (oak) 6.9 (cherry)
	6.0 (cherry)
20 to 25 m	9.9 7.8 8.8 13.0 (maple) 12.6 (maple)
	7.1 (birch) 9.5 (birch) 8.1 (cherry)
	7.6 (cherry)

270 Degree Heading

0 to 5 m	8.5 33.8 33.4 7.3 10.2 8.1
5 to 10 m	39.9 14.2 (oak) 9.4 (oak)
10 to 15 m	14.0 9.7 5.3 14.5 14.2 10.8 8.0
15 to 20 m	9.8 6.4 9.4 9.3 7.1 16.5 6.2(oak)

315 Degree Heading

0 to 5 m	(overlap)
5 to 10 m	39.8 5.3 7.6 7.2 11.6 11.8 5.0 (cherry)
10 to 15 m	8.5 10.0 13.0 7.9 (cherry) 10.5 (cherry)
15 to 20 m	17.2 15.9 17.3 15.8 16.5 21.2 11.0
	4.0 (cherry)
20 to 25 m	15.4 19.0 21.3 19.5 12.3 11.5 9.0 (maple)

TABLE B12

SUMMARY OF DIAMETER, TOTAL HEIGHT AND HEIGHT TO LOWEST LIVING BRANCHES FOR SPARSE JACK PINE SITE

Diameter (cm)	Height: Total (m)	Height: Lowest Branch (m)
7.4	4.11	.55
6.0	3.66	.73
7.0	3.66	.91
8.5	4.57	.55
10.6	5.03	.82
11.2	4.57	.46
7.9	4.11	1.10
9.7	4.11	.55
10.8	4.57	.64
7.6	4.11	.91
7.7	4.11	.64
9.6	5.03	.82
7.4	3.66	.64
8.2	5.03	.91
2.2	2.29	.37
6.5	3.66	.91
10.8	4.57	.82
6.0	4.11	1.01
9.7	4.57	.91
10.3	4.57	.73

DBH(cm)	HEIGHT(m)	LLBH(m)
7.4	4.11	.55
6.0	3.66	.73
7.0	3.66	.91
8.5	4.57	.55
10.6	5.03	.82
11.2	4.57	.46
7.9	4.11	1.10
9.7	4.11	.55
10.8	4.57	.64
7.6	4.11	.91
7.7	4.11	.64
9.6	5.03	.82
7.4	3.66	.64
8.2	5.03	.91
2.2	2.29	.37
6.5	3.66	.91
10.8	4.57	.82
6.0	4.11	1.01
9.7	4.57	.91
10.3	4.57	.73

TABLE B13

SUMMARY OF SPARSE JACK PINE DATE FROM
225 DEGREE LOOK DIRECTION

Site 1

X(m)	Y(m)	Diameter (cm)	Height (m)
-2.44	15.23	6.3	3.66
.91	14.93	6.3	4.27
1.22	12.19	5.5	3.96
3.66	11.78	9.2	4.88
-3.66	11.78	7.3	4.27
2.13	10.06	1.7	2.13
-2.44	9.14	6.1	3.96
.30	18.84	6.3	4.57
3.96	18.84	9.0	4.88
-1.22	7.93	7.5	4.27
2.13	7.32	8.5	4.57
.30	5.79	6.4	4.27
-3.66	3.05	7.4	3.96
3.96	3.05	6.8	4.27
-2.44	0.61	5.8	3.35
3.96	0.61	7.1	4.27
1.83	-1.83	5.6	3.66
4.57	-2.13	5.6	3.66
-1.22	-4.27	5.5	3.66
-2.74	-2.44	2.0	2.13
-3.96	-0.91	6.6	4.27

X-axis is oriented from 225° (-) to 45° (+)
Y-axis is oriented from 135° (-) to 315° (+)

TABLE B13 (continued)

SUMMARY OF SPARSE JACK PINE DATE FROM
225 DEGREE LOOK DIRECTION

Site 2

X(m)	Y(m)	Diameter (cm)	Height (m)
-1.22	-3.66	3.2	3.05
.00	-2.13	7.2	3.66
.91	-1.83	3.0	2.44
.91	-1.83	2.0	1.83
3.35	-2.13	3.7	3.66
3.35	-2.13	4.0	3.66
2.44	.61	6.9	3.96
4.57	-.30	9.1	4.27
.30	.91	6.1	3.05
1.22	5.79	3.0	2.44
3.35	4.57	6.8	3.35
2.74	6.40	3.1	2.44
2.74	6.40	3.0	2.44
4.27	8.23	2.1	2.13
.61	8.23	8.5	3.96
3.35	10.97	5.4	3.05
1.83	16.46	4.0	2.74
-1.83	15.85	6.1	3.35
-3.05	14.63	6.6	3.05
-.30	10.67	9.0	3.66
-3.05	10.97	5.9	2.74
-1.22	9.45	2.0	1.52
-.61	6.10	6.6	3.05
-3.66	5.79	7.5	3.05
-2.13	4.88	5.4	3.35
-3.35	3.96	7.9	3.35
-3.96	2.13	7.1	3.66
-3.05	.30	5.9	3.35
-1.22	-.91	5.1	2.44

X-axis is oriented from 225° (-) to 45° (+)
Y-axis is oriented from 135° (-) to 315° (+)

TABLE B13 (continued)

SUMMARY OF SPARSE JACK PINE DATE FROM
225 DEGREE LOOK DIRECTION

Site 3

X(m)	Y(m)	Diameter (cm)	Height (m)
-.61	15.54	6.8	3.35
.30	12.80	7.8	3.35
-3.96	12.50	1.0	1.22
-1.83	11.28	4.8	3.05
-1.83	11.28	4.2	3.05
4.27	12.80	8.0	3.66
2.13	11.28	1.0	.91
-3.35	10.06	8.4	3.96
-2.13	8.23	7.9	3.66
3.35	9.45	7.5	3.96
4.57	10.06	5.9	3.66
2.13	7.92	6.2	3.35
2.13	7.92	5.8	3.35
2.13	7.92	7.5	3.66
-.30	6.40	7.9	3.66
-3.96	7.32	5.0	3.05
.61	3.96	8.7	3.66
4.57	4.27	8.0	3.66
-2.13	1.52	8.7	3.35
-.30	.00	4.9	3.05
-.30	.00	5.0	3.05
3.96	.61	7.7	3.35
1.52	-2.13	6.6	3.35
.61	-3.35	7.3	3.66
4.57	-2.13	8.0	3.05
4.57	-4.57	7.8	3.96

X-axis is oriented from 225° (-) to 45° (+)
Y-axis is oriented from 135° (-) to 315° (+)

TABLE B13 (continued)

SUMMARY OF SPARSE JACK PINE DATE FROM
225 DEGREE LOOK DIRECTION

Site 4

X(m)	Y(m)	Diameter (cm)	Height (m)
-3.66	14.33	5.0	3.05
-1.22	13.72	3.1	3.35
-1.22	13.72	6.2	3.35
3.35	14.63	8.8	4.27
.91	11.89	8.2	4.27
-3.05	12.19	10.1	3.96
-.61	10.67	7.0	3.66
3.05	10.97	10.1	4.88
2.13	10.06	2.3	3.66
2.13	10.06	6.2	3.66
-1.83	9.45	7.0	3.66
.61	8.53	7.4	3.96
-2.44	5.79	8.9	4.27
.61	5.18	8.1	3.96
-1.22	3.66	7.2	3.66
2.44	3.96	8.2	4.27
1.52	3.05	9.2	4.27
3.05	1.52	9.9	4.88
-1.52	.30	1.0	1.83
.61	-1.22	7.8	4.27
-2.44	-1.22	8.7	4.88
-.91	-2.13	8.1	5.18
-1.22	-3.05	8.7	5.18
-4.57	-2.74	6.7	3.05

X-axis is oriented from 225° (-) to 45° (+)
Y-axis is oriented from 135° (-) to 315° (+)

TABLE B13 (continued)

SUMMARY OF SPARSE JACK PINE DATE FROM
225 DEGREE LOOK DIRECTION

Site 5

X(m)	Y(m)	Diameter (cm)	Height (m)
2.13	15.85	4.1	3.35
-1.52	15.24	9.7	4.57
-2.44	14.02	8.5	4.57
-4.88	15.24	1.0	1.52
.61	13.72	8.8	4.57
3.35	13.41	8.9	4.57
1.52	11.28	7.8	4.88
-2.74	10.97	1.0	1.83
-2.74	10.06	8.7	4.57
.00	9.14	6.7	4.27
-4.27	7.92	6.9	3.96
-1.52	7.32	6.9	3.66
2.44	6.40	1.0	1.52
-3.35	5.49	2.4	2.74
-.61	5.18	6.8	3.96
.91	3.35	8.5	4.27
-.61	.91	3.0	2.44
-3.66	1.22	7.2	4.27
.91	-1.22	7.5	3.66
2.74	-2.13	9.0	4.27
-.91	-3.05	7.5	4.27
.91	-4.57	7.5	4.57
-4.57	-.61	7.4	4.27
-4.27	-4.27	7.5	4.27

X-axis is oriented from 225° (-) to 45° (+)
Y-axis is oriented from 135° (-) to 315° (+)

TABLE B13 (continued)

SUMMARY OF SPARSE JACK PINE DATE FROM
225 DEGREE LOOK DIRECTION

Site 6

X(m)	Y(m)	Diameter (cm)	Height (m)
.61	15.54	1.0	.91
3.66	15.24	6.0	3.96
.91	14.63	1.0	1.52
-3.35	13.72	2.3	2.44
-.91	13.41	2.0	1.83
2.44	13.72	7.9	4.27
1.22	12.19	1.0	1.52
2.44	12.19	1.4	1.83
3.35	12.19	7.6	4.57
.61	9.75	1.0	1.22
2.44	10.06	1.0	1.22
-1.52	11.89	1.0	.91
.91	8.53	7.1	3.66
-2.44	8.53	1.0	.91
-3.66	7.62	4.5	2.74
-.61	7.01	7.8	3.66
2.74	7.62	8.8	4.27
1.83	6.40	6.7	4.27
3.96	5.79	2.0	1.83
2.13	5.49	1.0	1.22
-2.13	5.18	8.4	3.96
.30	4.88	6.6	3.66
2.44	3.66	1.0	.91
2.13	3.35	1.0	.91
1.83	3.05	1.0	.91
-3.05	4.27	1.0	.91
-3.66	3.96	6.6	3.66
-2.13	2.74	4.5	3.05
3.35	1.83	6.5	3.96
.00	1.22	2.5	2.44
-.91	.30	4.0	3.35
1.52	.30	1.0	1.22
-3.35	.30	1.0	.91
2.74	-4.88	1.0	.61
.00	-1.83	3.6	2.13
-2.44	-.91	4.2	3.05
-3.35	-.91	1.0	.91
-1.83	-3.05	1.5	1.83
-2.44	-4.27	1.0	.91
-2.13	-4.57	1.0	1.22
-4.57	-3.66	6.4	3.96
-4.57	-3.66	5.1	3.96

TABLE B13 (concluded)

SUMMARY OF SPARSE JACK PINE DATE FROM
225 DEGREE LOOK DIRECTION

X-axis is oriented from 225° (-) to 45° (+)
Y-axis is oriented from 135° (-) to 315° (+)

TABLE B14

SUMMARY OF SPARSE JACK PINE DATE FROM
270 DEGREE LOOK DIRECTION

Site 1

Distance North(+) South(-) (m)	Distance East(+) West(-) (m)	Diameter (cm)
-2.6	4.5	7.3
3.0	4.5	5.7
5.8	4.5	8.3
8.5	4.5	8.9
13.7	4.5	7.6
-5.0	2.0	6.4
-2.0	2.0	6.4
8.6	2.0	6.4
13.8	2.0	7.3
16.4	2.0	5.4
-4.1	-.5	1.3
5.3	-.5	6.7
8.0	-.5	5.1
11.0	-.5	6.4
13.3	-.5	7.3
19.5	-.5	6.4
-3.6	-2.7	3.8
.6	-2.7	5.7
4.4	-2.7	7.0
15.0	-2.7	6.0
-2.8	-5.2	6.4
4.0	-5.2	6.0
10 4	-5.2	5.7
16.7	-5.2	6.7
20.0	-5.2	9.2

TABLE B14 (continued)

SUMMARY OF SPARSE JACK PINE DATE FROM
270 DEGREE LOOK DIRECTION

Site 2

Distance North(+) South(-) (m)	East(+) West(-) (m)	Diameter (cm)
-3.4	5.0	6.4
-1.4	5.0	7.0
1.1	5.0	7.0
3.2	5.0	5.7
5.1	5.0	7.0
7.4	5.0	7.6
11.7	5.0	3.8
-3.6	2.7	.6
-1.7	2.7	4.4
5.3	2.7	2.5
7.6	2.7	2.5
9.7	2.7	1.3
11.7	2.7	5.1
14.5	2.7	1.3
20.0	2.7	7.0
-1.2	.2	2.5
1.2	.2	5.7
6.3	.2	7.0
8.0	.2	7.0
11.2	.2	5.7
13.0	.2	1.3
15.7	.2	1.3
18.2	.2	7.0
20.4	.2	6.4
-4.1	-2.5	2.5
-2.0	-2.5	7.0
-.3	-2.5	2.5
2.0	-2.5	7.0
6.5	-2.5	4.8
9.2	-2.5	7.3
11.2	-2.5	9.2
13.6	-2.5	4.1
18.0	-2.5	7.6
21.0	-2.5	7.0
-5.4	-5.0	7.3
.9	-5.0	3.2
3.0	-5.0	8.3

TABLE B14 (continued)

SUMMARY OF SPARSE JACK PINE DATE FROM
270 DEGREE LOOK DIRECTION

Site 2 (continued)

Distance North(+) South(-) (m)	Distance East(+) West(-) (m)	Diameter (cm)
4.8	-5.0	5.4
4.8	-5.0	5.7
6.9	-5.0	5.4
8.6	-5.0	4.8
10.7	-5.0	7.6
12.9	-5.0	5.1
17.2	-5.0	4.1
19.2	-5.0	6.4
21.1	-5.0	3.8

TABLE B14 (continued)

SUMMARY OF SPARSE JACK PINE DATE FROM
270 DEGREE LOOK DIRECTION

Site 3

Distance North(+) South(-) (m)	East(+) West(-) (m)	Diameter (cm)
4.0	5.7	7.9
7.3	5.7	5.1
7.3	5.7	5.1
8.7	5.7	7.3
11.0	5.7	5.1
14.2	5.7	7.0
16.2	5.7	4.4
18.6	5.7	6.6
20.6	5.7	8.2
-.5	3.4	7.9
3.5	3.4	8.2
10.1	3.4	3.6
14.6	3.4	8.2
16.7	3.4	2.5
20.6	3.4	5.4
20.6	3.4	4.7
-.2	.7	4.4
-.2	.7	4.4
7.0	.7	8.5
11.0	.7	7.6
12.5	.7	7.6
17.3	.7	9.5
-2.5	-1.8	7.3
-.6	-1.8	6.3
4.0	-1.8	7.6
6.0	-1.8	5.1
7.7	-1.8	4.1
9.7	-1.8	3.2
11.7	-1.8	3.4
21.7	-1.8	2.5
-5.0	-4.3	5.7
2.5	-4.3	7.9
8.8	-4.3	7.3
10.3	-4.3	6.6
18.5	-4.3	7.6
20.8	-4.3	5.1

TABLE B14 (continued)

SUMMARY OF SPARSE JACK PINE DATE FROM
270 DEGREE LOOK DIRECTION

Site 4

Distance North(+) South(-) (m)	East(+) West(-) (m)	Diameter (cm)
-4.0	6.0	8.3
3.0	6.0	8.3
7.7	6.0	6.7
9.6	6.0	5.4
11 5	6.0	8.3
15.5	6.0	2.5
17.2	6.0	2.5
20.0	6.0	7.3
3.1	3.4	7.0
5.4	3.4	8.3
11.6	3.4	7.0
13.7	3.4	3.8
20.8	3.4	3.8
-5.3	1.4	6.4
-2.5	1.4	8.6
3.3	1.4	8.6
5.0	1.4	7.9
9.3	1.4	7.3
14.1	1.4	5.1
16.2	1.4	7.6
18.2	1.4	5.4
20.0	1.4	6.7
-3.0	-1.0	8.3
-1.5	-1.0	7.9
-.2	-1.0	8.6
3.4	-1.0	9.5
17.2	-1.0	12.4
21.7	-1.0	4.8
-3.5	-3.6	3.8
3.5	-3.6	5.4
5.6	-3.6	8 3
-5.0	-6.3	7.6
6.3	-6.3	6.0
8.4	-6.3	8.6
13.0	-6.3	6.0

TABLE B14 (continued)

SUMMARY OF SPARSE JACK PINE DATE FROM
270 DEGREE LOOK DIRECTION

Site 5

Distance North(+) South(-) (m)	East(+) West(-) (m)	Diameter (cm)
-4.5	7.1	7.0
-2.0	7.1	7.0
3.0	7.1	5.7
11.2	7.1	7.0
.0	4.4	1.9
2.8	4.4	8.3
5.1	4.4	6.0
7.8	4.4	2.5
13.4	4.4	6.0
13.4	4.4	6.7
16.0	4.4	9.5
-4.0	1.7	7.0
-1.4	1.7	7.0
11.6	1.7	7.6
15.0	1.7	6.4
18.4	1.7	8.6
19.3	1.7	5.4
-4.1	-1.0	7.0
-1.3	-1.0	9.5
1.8	-1.0	8.3
4.4	-1.0	6.4
8.0	-1.0	8.3
10.7	-1.0	2.5
13.2	-1.0	2.5
15.8	-1.0	2.5
-3.7	-3.5	8.3
2.5	-3.5	7.6
4.3	-3.5	9.5
7.3	-3.5	7.9
9.7	-3.5	2.5
11.5	-3.5	6.4
13.5	-3.5	7.0
17.7	-3.5	6.7
21.0	-3.5	6.0
8.6	-6.2	4.8
11.6	-6.2	9.5
17.5	-6.2	7.6
20.0	-6.2	8.6

TABLE B14 (concluded)

SUMMARY OF SPARSE JACK PINE DATE FROM
270 DEGREE LOOK DIRECTION

Site 6

Distance North(+) South(-) (m)	Distance East(+) West(-) (m)	Diameter (cm)
-1.4	5.2	2.0
6.0	5.2	2.4
3.0	5.2	3.3
5.4	5.2	2.9
7.3	5.2	3.0
11.7	5.2	2.9
13.7	5.2	2.0
15.8	5.2	3.0
1.0	2.8	1.0
4.4	2.8	2.5
6.2	2.8	2.6
8.0	2.8	3.3
-3.1	.5	1.0
-3.0	.5	1.0
1.0	.5	.5
7.0	.5	.5
6.5	.5	1.8
10.5	.5	1.9
12.6	.5	3.3
15.0	.5	1.8
17.4	.5	2.6
21.0	.5	2.6

TABLE B15

SUMMARY OF DIAMETER, TOTAL HEIGHT AND HEIGHT TO LOWEST LIVING BRANCHES FOR MEDIUM JACK PINE SITE

Diameter (cm)	Height: Total (m)	Height: Lowest Branch (m)
11.5	5.03	1.28
11.1	5.49	1.28
9.0	5.49	1.10
9.0	5.67	.55
10.1	5.49	.55
14.0	6.68	.55
9.6	5.49	1.28
12.0	5.03	1.19
15.6	8.23	1.01
12.7	6.58	1.37
14.5	7.77	1.28
11.1	6.86	1.10
12.2	5.49	1.10
13.5	7.32	1.28
11.0	6.40	.73
11.7	5.94	.91
16.1	7.77	1.19
11.7	6.40	1.19
11.3	6.40	1.28
12.0	5.94	1.37

TABLE B16

SUMMARY OF DIAMETER AND HEIGHT DATA FOR
MEDIUM JACK PINE SITES

Site 1

Distance North (+) South (-) (m)	Distance East (+) West (-) (m)	Diameter (cm)
2.13	-.30	11.7
2.13	-2.44	11.0
2.13	-4.27	10.5
2.13	3.35	11.2
-4.88	-5.49	10.0
-4.88	-3.96	11.0
-4.88	1.52	10.5
-4.88	3.35	14.0
-1.22	-6.40	11.5
-1.22	-1.83	7.8
-1.22	1.83	6.5
-1.22	3.66	12.0
5.49	-3.66	11.8
5.18	-.91	7.0
5.18	-.61	12.5
5.49	1.22	11.0
5.49	3.35	12.2
6.40	-4.27	11.5
6.40	1.71	11.0
6.40	3.05	9.5
6.40	3.35	8.2
11.89	-6.40	8.8
11.89	-18.59	11.0
11.89	-3.05	5.8
11.89	-1.83	5.0
11.89	1.52	9.5
11.89	3.66	14.0
11.89	5.18	9.0
13.72	-3.96	9.8
12.80	-2.44	18.0
13.72	3.66	8.7
18.29	-4.88	10.5
18.29	-2.74	12.0
18.29	-.91	10.0
18.29	2.74	10.7
21.34	1.52	9.5
21.34	3.66	11.8
21.34	6.10	7.2

TABLE B16 (continued)

SUMMARY OF DIAMETER AND HEIGHT DATA FOR MEDIUM JACK PINE SITES

Site 2

Distance North (+) South (-) (m)	East (+) West (-) (m)	Diameter (cm)
-6.10	-.30	11.0
-6.10	3.66	12.0
-6.10	5.49	10.5
-3.35	-6.71	11.0
-3.35	-3.05	9.0
-3.35	-.91	10.3
-3.35	.61	7.0
-3.35	.61	11.0
-3.35	2.74	8.5
-3.35	4.57	3.7
-.30	-4.88	10.5
-.30	-3.05	12.3
-.30	-1.22	7.5
-.30	.61	12.0
-.30	2.13	11.5
-.30	3.96	6.8
2.74	-6.10	9.0
2.74	-6.10	3.8
2.74	-3.96	12.5
2.74	-1.83	8.6
2.74	2.13	14.0
5.79	-3.66	13.0
5.79	-1.83	8.5
5.79	.30	10.5
9.14	-4.57	8.5
9.14	.61	8.3
9.14	3.66	9.8
12.19	-4.27	10.5
12.19	-3.05	7.0
12.19	-1.52	10.8
12.19	.61	12.8
12.19	3.96	11.0
12.19	3.96	5.5
12.19	6.10	10.8
15.24	-4.88	11.5

TABLE B16 (continued)

SUMMARY OF DIAMETER AND HEIGHT DATA FOR
MEDIUM JACK PINE SITES

Site 2 (continued)

Distance North (+) South (-) (m)	Distance East (+) West (-) (m)	Diameter (cm)
15.24	-1.52	10.7
15.24	.15	11.0
15.24	2.74	13.0
15.24	4.57	8.5
16.15	-6.10	6.2
16.15	-2.74	11.5
18.90	2.44	10.0
21.34	-6.10	6.5
21.34	-1.83	10.5
21.34	2.13	8.5
21.34	5.18	8.3

TABLE B16 (continued)

SUMMARY OF DIAMETER AND HEIGHT DATA FOR MEDIUM JACK PINE SITES

Site 3

Distance North (+) South (-) (m)	Distance East (+) West (-) (m)	Diameter (cm)
-6.40	-6.10	13.0
-6.40	-1.52	11.0
-6.40	3.66	14.3
-6.40	4.57	5.8
-3.05	-6.40	11.0
-3.05	-3.66	11.8
-3.05	-1.22	8.5
-3.05	.91	8.3
-3.05	2.74	10.2
-3.05	4.57	10.0
-3.05	6.71	12.2
-.30	-1.52	11.5
-.30	.61	10.5
-.30	2.74	10.5
-.30	4.88	9.8
-.30	4.88	9.8
-.30	6.71	11.5
3.05	-1.52	5.8
3.05	-1.22	11.2
5.49	5.79	10.5
7.62	-6.10	8.0
7.62	-2.44	9.8
7.62	-.61	11.0
7.62	1.22	9.8
12.19	-4.88	6.0
12.19	-2.13	2.7
12.19	2.44	1.0
12.19	5.79	9.5
15.24	-1.83	9.5
15.24	2.13	10.0
15.24	4.57	8.3
15.24	6.71	10.3
18.29	-1.83	11.8
18.29	4.27	15.5
18.29	6.10	11.8
21.34	-6.40	11.8

TABLE B16 (continued)

SUMMARY OF DIAMETER AND HEIGHT DATA FOR MEDIUM JACK PINE SITES

Site 4

Distance North (+) South (-) (m)	Distance East (+) West (-) (m)	Diameter (cm)
-7.62	-1.52	12.5
-7.62	3.66	9.2
-4.88	-5.49	13.5
-4.88	-3.35	7.7
-1.22	-4.27	11.0
-1.22	-1.83	7.0
-1.22	1.52	8.7
-1.22	1.52	8.7
-1.22	4.57	7.0
1.83	-5.79	9.3
4.57	-4.27	13.0
4.57	-1.52	10.8
4.57	1.22	14.5
4.57	4.27	12.5
7.92	-3.05	9.3
7.92	-1.22	8.0
7.92	1.22	6.5
7.92	3.66	11.3
7.92	6.10	11.3
9.14	-5.49	1.0
9.14	-2.44	8.0
14.02	-4.57	2.5
14.02	-2.74	3.5
14.02	3.66	5.7
17.07	-5.49	11.5
17.07	-3.66	10.0
17.07	-1.83	10.0
17.07	1.52	14.0
17.07	4.57	11.0
20.42	-2.13	9.0
20.42	3.35	1.0

Site 6

21.03	-2.13	13.0	5.5
15.54	-3.66	11.3	6.7
14.63	-.30	7.0	4.6
13.11	-3.35	1.4	2.4
13.11	-3.35	1.5	2.1

TABLE B16 (continued)

SUMMARY OF DIAMETER AND HEIGHT DATA FOR
MEDIUM JACK PINE SITES

Site 4 (continued)

Distance North (+) South (-) (m)	Distance East (+) West (-) (m)	Diameter (cm)	
12.19	-1.22	8.0	4.3
6.10	-4.57	1.0	1.1
5.49	-1.83	2.5	2.4
1.83	-2.74	11.0	4.9
1.83	-1.22	1.0	1.2
.30	-5.79	9.0	4.6
-1.83	-1.83	3.2	3.1
-4.27	-.91	2.1	3.1
-4.27	-.91	3.2	3.7
-5.18	-1.22	1.0	1.8
-5.49	-2.44	5.4	4.3
-5.49	-2.44	8.8	4.9
-6.10	.61	1.5	2.1
-5.79	.00	5.2	4.0
-3.66	3.35	7.2	4.6
-3.05	.61	5.3	4.3
-1.83	4.88	1.0	1.2
-1.83	5.49	3.0	3.7
-1.83	5.49	3.5	3.7
.91	.00	1.0	2.1
.61	2.74	5.3	3.7
2.44	3.66	1.0	1.2
5.49	6.10	1.0	1.2
9.45	4.88	10.0	5.2
10.67	3.05	12.0	5.2
11.58	1.22	7.0	4.3
16.46	4.88	12.2	5.2
17.68	1.52	11.5	5.2
17.98	5.79	2.0	2.7
19.20	4.88	15.0	6.7
20.73	1.83	9.5	5.2

TABLE B16 (continued)

SUMMARY OF DIAMETER AND HEIGHT DATA FOR
MEDIUM JACK PINE SITES

Site 5

Distance North (+) South (-) (m)	Distance East (+) West (-) (m)	Diameter (cm)	Height (m)
-6.10	.30	8.1	6.7
-3.05	.91	6.5	5.2
-3.05	4.57	8.9	5.5
-1.22	4.88	10.5	6.4
.00	3.35	5.7	4.9
-.30	5.79	6.5	5.5
3.35	1.22	7.7	6.4
3.35	4.27	9.8	6.1
3.35	5.79	10.0	5.5
5.79	1.52	10.2	6.7
6.10	4.57	12.3	7.3
6.10	6.10	8.3	6.1
9.45	3.05	9.8	6.7
9.45	3.05	10.0	7.0
9.14	4.88	1.5	2.4
11.28	5.79	9.5	6.7
13.11	.61	5.0	4.9
16.15	4.27	1.0	1.5
16.46	5.49	1.0	1.5
19.51	.00	11.5	6.7
20.42	-1.83	8.8	6.1
20.42	-3.66	10.0	5.8
20.42	-5.79	46.0	1.8
18.29	-6.10	14.0	7.3
18.29	-4.57	14.0	6.7
15.54	-4.88	7.0	3.0
12.50	-3.35	11.5	7.0
12.50	-1.22	10.5	6.7
9.14	-6.40	12.7	7.3
9.14	-4.88	9.5	5.2
9.14	-2.44	9.0	7.9
9.14	-.30	11.8	7.0
4.27	-1.83	3.8	2.7
-.61	-4.27	8.5	5.2
-2.44	-5.79	14.0	7.6
-.61	-2.13	2.3	3.0
-.61	-.30	11.5	7.9
-3.66	-5.79	9.3	6.7

TABLE B16 (concluded)

SUMMARY OF DIAMETER AND HEIGHT DATA FOR MEDIUM JACK PINE SITES

Site 5

Distance North (+) South (-) (m)	Distance East (+) West (-) (m)	Diameter (cm)	Height (m)
21.03	-2.13	13.0	5.5
15.54	-3.66	11.3	6.7
14.63	-.30	7.0	4.6
13.11	-3.35	1.4	2.4
13.11	-3.35	1.5	2.1
12.19	-1.22	8.0	4.3
6.10	-4.57	1.0	1.1
5.49	-1.83	2.5	2.4
1.83	-2.74	11.0	4.9
1.83	-1.22	1.0	1.2
.30	-5.79	9.0	4.6
-1.83	-1.83	3.2	3.1
-4.27	-.91	2.1	3.1
-4.27	-.91	3.2	3.7
-5.18	-1.22	1.0	1.8
-5.49	-2.44	5.4	4.3
-5.49	-2.44	8.8	4.9
-6.10	.61	1.5	2.1
-5.79	.00	5.2	4.0
-3.66	3.35	7.2	4.6
-3.05	.61	5.3	4.3
-1.83	4.88	1.0	1.2
-1.83	5.49	3.0	3.7
-1.83	5.49	3.5	3.7
.91	.00	1.0	2.1
.61	2.74	5.3	3.7
2.44	3.66	1.0	1.2
5.49	6.10	1.0	1.2
9.45	4.88	10.0	5.2
10.67	3.05	12.0	5.2
11.58	1.22	7.0	4.3
16.46	4.88	12.2	5.2
17.68	1.52	11.5	5.2
17.98	5.79	2.0	2.7
19.20	4.88	15.0	6.7
20.73	1.83	9.5	5.2

TABLE B17

SUMMARY OF AVERAGE STAND MEASUREMENTS
FOR DENSE JACK PINE SITES

	Total Trees	Trees per Hectare	Diameter Average (cm)	Diameter Std Dev	Height Average (m)	Height Std Dev
Site 1						
Entire Site						
Live J. Pine	104	662	20.0	7.00	18.5	1.70
Dead J. Pine	25	159	15.8	6.36	17.4	1.54
Total J. Pine	129	821	19.2	7.08	18.3	1.71
Deciduous	3	19	8.7	1.25		
Total Site	132	840	18.9	7.18		
Reflector Only						
Live J. Pine	36	859	20.8	6.72	18.7	1.63
Dead J. Pine	4	95	15.8	5.71	17.4	1.38
Total J. Pine	40	954	20.3	6.80	18.5	1.64
Deciduous	2	48	8.5	1.50		
Total Site	42	1003	19.8	7.10		
Site 2						
Entire stand						
Live J. Pine	91	508	22.4	15.83	19.1	3.85
Dead J. Pine	6	33	12.8	2.97	17.3	.91
Total J. Pine	97	541	22.0	15.54	19.0	3.79
Deciduous	43	240	15.8	7.56		
Total Site	150	837	20.0	13.91		
Reflector only						
Live J. Pine	40	604	19.2	5.99	18.3	1.45
Dead J. Pine	5	76	13.9	3.31	17.1	.87
Total J. Pine	45	680	18.6	5.99	18.2	1.45
Deciduous	8	121	21.4	8.45		
Total Site	53	801	19.0	6.50		

TABLE B17 (continued)

SUMMARY OF AVERAGE STAND MEASUREMENTS
FOR DENSE JACK PINE SITES

	Total Trees	Trees per Hectare	Diameter Average (cm)	Diameter Std Dev	Height Average (m)	Height Std Dev
Site 3						
Entire Stand						
Live J. Pine	141	652	19.1	4.76	18.3	1.52
Dead J. Pine	63	291	14.6	5.04	17.2	1.22
Total J. Pine	204	943	17.7	5.26	17.9	1.27
Deciduous	11	51	13.3	7.49		
Total Site	215	994	17.5	5.49		
Reflector Only						
Live J. Pine	39	511	20.4	5.30	18.6	1.28
Dead J. Pine	27	354	15.7	5.61	17.4	1.35
Total J. Pine	66	864	18.5	5.91	17.7	1.42
Deciduous	5	65	10.4	3.25		
Total Site	71	930	17.9	6.13		
Site 4						
Entire Stand						
Live J. Pine	153	707	17.3	5.49	17.8	1.33
Dead J. Pine	35	162	14.3	5.37	17.1	1.30
Total J. Pine	188	869	16.7	5.59	17.7	1.35
Deciduous	26	120	15.9	5.24		
Total Site	214	989	16.6	5.56		
Reflector only						
Live J. Pine	37	424	18.64	5.76	18.2	1.38
Dead J. Pine	7	80	13.29	2.83	16.9	.68
Total J. Pine	44	504	17.8	5.74	18.0	1.38
Deciduous	5	57	15.10	4.96		
Total Site	49	561	17.51	5.73		

TABLE B17 (concluded)

SUMMARY OF AVERAGE STAND MEASUREMENTS
FOR DENSE JACK PINE SITES

	Total Trees	Trees per Hectare	Diameter Average (cm)	Diameter Std Dev	Height Average (m)	Height Std Dev
Site 5						
Entire Stand						
Live J. Pine	86	397	20.46	6.46	18.6	1.54
Dead J. Pine	3	14	20.50	12.79	18.6	3.09
Total J. Pine	89	401	20.6	6.72	18.6	1.63
Deciduous	12	55	20.92	13.40		
Total Site	101	456	20.6	7.84		
Reflector only						
Live J. Pine	20	229	20.83	6.83	18.7	1.65
Dead J. Pine	1	11	13.00		16.8	
Total J. Pine	21	240	20.5	6.87	18.6	1.66
Deciduous	8	92	16.38	3.46		
Total Site	29	321	19.3	6.39		

TABLE B18

SUMMARY OF DIAMETER, TOTAL HEIGHT AND HEIGHT TO LOWEST LIVING BRANCH FOR DENSE JACK PINE STAND

	Height	
	Total	Lowest Branch
(cm)	(m)	(m)
33.7	17.4	2.7
18.6	15.5	6.4
17.9	15.5	6.4
15.2	18.7	9.1
21.1	17.4	5.9
26.0	22.4	11.9
22.4	19.9	11.9
24.9	22.4	15.1
22.0	19.2	7.3
17.8	16.5	10.1
22.5	21.5	13.7
35.8	23.8	11.0
25.4	19.7	10.5
23.8	20.1	13.7
25.6	17.8	10.5
20.7	20.1	14.6
24.2	18.7	8.2
25.8	19.7	10.5
26.2	23.8	12.8
20.1	20.1	13.3
21.7	18.1	13.5
25.9	21.8	11.4
30.8	20.1	11.0
29.4	21.0	11.9
27.1	19.2	11.9
24.7	16.0	12.8
17.4	16.9	13.7
15.9	13.7	9.1
13.5	17.8	13.3
21.8	22.9	15.5
15.6	18.7	15.1
27.3	24.9	16.5
29.4	21.9	11.4
31.8	19.7	10.5
21.3	19.2	11.0
29.3	16.0	6.9
17.2	17.4	11.4
24.9	20.6	14.2
25.3	19.2	9.1
18.3	15.5	7.3
23.7	21.0	8.7

TABLE B19

HEADING, DISTANCE, AND DIAMETER DATA FOR DENSE JACK PINE STANDS

Site 1

Heading	Distance (m)	Diameter (cm)	Species
4	18.9	26.0	Jack Pine
5	15.8	23.4	Jack Pine
10	7.6	24.5	Jack Pine
10	10.7	30.5	Jack Pine
10	19.5	28.0	Jack Pine
15	15.2	20.8	Dead J. Pine
17	16.5	23.1	Dead J. Pine
30	9.4	19.0	Jack Pine
30	15.5	18.0	Jack Pine
50	13.1	42.1	Jack Pine
50	16.2	22.5	Jack Pine
76	18.3	20.5	Jack Pine
76	13.7	8.0	Jack Pine
76	22.9	27.5	Jack Pine
76	40.5	25.5	Jack Pine
77	33.8	10.0	Maple
77	40.5	24.5	Jack Pine
78	5.8	7.0	Oak
78	30.5	13.5	Jack Pine
79	22.9	16.5	Jack Pine
80	37.2	16.5	Dead J. Pine
80	28.7	23.0	Jack Pine
80	29.3	11.5	Jack Pine
80	37.2	15.0	Jack Pine
81	16.8	23.0	Jack Pine
81	15.2	25.0	Jack Pine
82	37.2	18.0	Dead J. Pine
83	28.3	6.5	Dead J. Pine
83	27.7	19.0	Jack Pine
83	32.6	27.0	Jack Pine
83	37.5	22.0	Jack Pine
83	37.8	26.0	Jack Pine
84	18.3	23.0	Jack Pine
84	18.3	5.5	Jack Pine
85	15.8	22.0	Dead J. Pine
86	32.3	25.5	Jack Pine
89	37.8	22.5	Jack Pine
90	35.7	11.5	Jack Pine
93	35.4	14.5	Jack Pine
93	36.3	23.0	Jack Pine
94	31.1	17.0	Jack Pine

TABLE B19 (continued)

HEADING, DISTANCE, AND DIAMETER DATA FOR DENSE JACK PINE STANDS

Site 1 (continued)

Heading	Distance (m)	Diameter (cm)	Species
94	34.1	16.5	Jack Pine
95	4.6	28.0	Jack Pine
95	27.7	32.5	Jack Pine
97	14.6	28.0	Jack Pine
97	34.4	23.0	Jack Pine
97	35.7	21.5	Jack Pine
98	21.9	17.5	Jack Pine
100	24.7	8.0	Jack Pine
100	25.0	18.0	Jack Pine
103	37.5	33.0	Jack Pine
105	14.3	25.0	Jack Pine
105	34.1	29.0	Jack Pine
110	3.4	20.5	Jack Pine
110	12.2	16.5	Jack Pine
115	9.1	26.0	Jack Pine
117	11.6	8.0	Jack Pine
117	14.6	22.0	Dead J. Pine
127	12.5	15.5	Jack Pine
130	16.5	9.5	Dead J. Pine
132	9.8	5.0	Jack Pine
133	7.9	24.0	Jack Pine
133	18.6	28.0	Jack Pine
143	20.1	30.0	Jack Pine
145	5.2	25.0	Jack Pine
148	12.2	18.0	Jack Pine
148	14.0	9.5	Jack Pine
148	12.2	7.0	Dead J. Pine
153	10.4	13.0	Jack Pine
153	10.7	15.5	Jack Pine
157	17.1	16.5	Jack Pine
162	9.1	14.0	Jack Pine
162	10.4	11.3	Jack Pine
163	13.7	9.0	Jack Pine
165	4.0	7.0	Jack Pine
165	17.7	20.5	Jack Pine
165	7.6	17.0	Dead J. Pine
172	11.6	12.0	Jack Pine
177	18.3	15.0	Jack Pine
178	17.1	9.0	Dead Oak
180	11.3	22.5	Jack Pine

TABLE B19 (continued)

HEADING, DISTANCE, AND DIAMETER DATA FOR DENSE JACK PINE STANDS

Site 1 (continued)

Heading	Distance (m)	Diameter (cm)	Species
180	18.6	21.0	Jack Pine
182	10.4	12.5	Jack Pine
185	11.3	15.5	Jack Pine
197	18.0	16.5	Jack Pine
205	8.2	20.0	Jack Pine
207	10.7	13.0	Jack Pine
223	7.0	20.0	Jack Pine
225	17.4	11.0	Dead J. Pine
227	13.1	13.5	Jack Pine
227	13.7	28.5	Jack Pine
227	15.2	15.0	Dead J. Pine
230	4.9	17.0	Jack Pine
230	15.2	10.5	Dead J. Pine
242	3.4	8.5	Jack Pine
242	12.8	13.0	Jack Pine
260	16.2	15.0	Jack Pine
265	8.5	12.0	Jack Pine
265	13.4	23.0	Jack Pine
268	8.5	19.5	Jack Pine
268	10.1	11.0	Dead J. Pine
275	10.4	21.5	Jack Pine
277	13.7	18.5	Jack Pine
277	16.8	31.0	Jack Pine
280	4.9	15.2	Dead J. Pine
280	12.5	11.0	Dead J. Pine
283	10.4	15.5	Dead J. Pine
290	12.2	30.7	Jack Pine
295	12.8	11.5	Jack Pine
300	5.5	27.2	Jack Pine
300	3.7	11.0	Dead J. Pine
305	9.1	35.0	Dead J. Pine
320	18.9	27.0	Jack Pine
325	13.4	24.1	Jack Pine
325	15.8	21.6	Jack Pine
325	19.2	24.8	Jack Pine
330	19.8	17.4	Jack Pine
330	9.8	12.1	Jack Pine
335	4.0	7.0	Dead J. Pine
335	13.7	20.8	Dead J. Pine
337	18.3	30.6	Jack Pine
337	18.9	22.0	Jack Pine
337	12.8	18.5	Dead J. Pine

TABLE B19 (continued)

HEADING, DISTANCE, AND DIAMETER DATA FOR DENSE JACK PINE STANDS

Site 1 (concluded)

Heading	Distance (m)	Diameter (cm)	Species
337	14.3	18.5	Dead J. Pine
340	2.4	24.3	Jack Pine
340	3.7	24.1	Jack Pine
350	4.6	12.1	Jack Pine
350	12.2	15.0	Jack Pine
355	7.0	28.2	Jack Pine
357	8.5	21.7	Jack Pine
360	4.6	11.5	Dead J. Pine
360	18.9	20.4	Dead J. Pine

TABLE B19 (continued)

HEADING, DISTANCE, AND DIAMETER DATA FOR DENSE JACK PINE STANDS

Site 2

Heading	Distance (m)	Diameter (cm)	Species
0	14.9	9.5	Jack Pine
0	11.6	22.0	Jack Pine
0	20.1	28.0	Jack Pine
0	14.9	17.0	Aspen
5	7.3	8.5	Jack Pine
5	14.6	9.5	Jack Pine
5	10.4	12.0	Aspen
10	7.9	9.0	Jack Pine
10	9.8	24.0	Jack Pine
15	19.8	15.0	Oak
17	17.4	11.5	Aspen
20	13.4	29.0	Jack Pine
30	18.0	25.5	Jack Pine
30	17.4	15.0	Oak
35	17.4	18.5	Oak
38	11.0	8.0	Aspen
45	14.3	18.0	Aspen
50	9.4	17.5	Aspen
55	11.9	15.5	Aspen
65	9.8	20.5	Jack Pine
65	8.5	7.0	Aspen
65	10.4	10.5	Oak
67	10.7	21.5	Jack Pine
74	7.6	22.0	Jack Pine
74	8.5	24.5	Jack Pine
75	44.8	17.0	Jack Pine
75	47.5	22.0	Jack Pine
75	47.9	23.5	Jack Pine
75	48.5	23.0	Jack Pine
75	48.5	23.5	Jack Pine
75	48.8	28.0	Jack Pine
75	7.9	21.0	Jack Pine
75	14.6	29.0	Aspen
80	15.8	9.5	Dead J. Pine
82.5	32.3	32.5	Jack Pine
85	9.4	17.5	Jack Pine
85	33.8	25.0	Jack Pine
85	19.5	28.0	Aspen
87	22.3	27.5	Jack Pine
88	33.5	12.5	Jack Pine

TABLE B19 (continued)

HEADING, DISTANCE, AND DIAMETER DATA FOR DENSE JACK PINE STANDS

Site 2 (continued)

Heading	Distance (m)	Diameter (cm)	Species
90	32.0	21.5	Jack Pine
90	6.7	22.0	Jack Pine
90	29.6	13.0	Jack Pine
90	29.9	15.5	Jack Pine
90	37.8	33.0	Jack Pine
90	21.0	29.5	Aspen
91	18.6	12.0	Jack Pine
91	25.3	19.0	Jack Pine
91	30.2	13.0	Jack Pine
92	7.9	26.0	Jack Pine
92	17.4	19.5	Aspen
93	29.3	20.0	Jack Pine
94	18.3	25.0	Jack Pine
95	21.9	11.5	Jack Pine
95	29.6	13.5	Jack Pine
95	12.5	29.0	Aspen
95	17.7	10.0	Aspen
97.5	22.9	9.0	Jack Pine
97.5	26.8	17.5	Jack Pine
97.5	27.4	19.0	Jack Pine
97.5	30.8	12.0	Jack Pine
97.5	34.4	9.5	Jack Pine
97.5	32.9	11.5	Jack Pine
97.5	33.5	12.5	Dead J. Pine
97.5	11.9	7.0	Aspen
100	25.9	18.5	Jack Pine
100	32.0	20.5	Jack Pine
100	37.5	27.0	Jack Pine
100	32.6	17.5	Dead J. Pine
100	36.3	12.0	Dead J. Pine
100	30.5	18.0	Dead J. Pine
102	26.8	18.5	Jack Pine
102	28.3	17.5	Jack Pine
103	22.6	15.0	Jack Pine
103	31.7	12.5	Jack Pine
103	11.0	19.0	Dead Aspen
105	34.4	20.5	Jack Pine
105	37.5	21.0	Jack Pine
120	2.4	24.5	Jack Pine
125	11.3	25.0	Jack Pine

TABLE B19 (continued)

HEADING, DISTANCE, AND DIAMETER DATA FOR DENSE JACK PINE STANDS

Site 2 (continued)

Heading	Distance (m)	Diameter (cm)	Species
125	16.5	27.0	Jack Pine
125	17.1	21.0	Jack Pine
125	17.4	16.5	Jack Pine
125	19.2	17.0	Jack Pine
125	16.5	27.0	Jack Pine
125	17.1	21.0	Jack Pine
125	17.4	16.5	Jack Pine
125	19.2	17.0	Jack Pine
130	15.8	9.5	Aspen
135	14.3	28.5	Jack Pine
140	12.5	21.5	Jack Pine
140	14.0	14.5	Jack Pine
140	3.7	17.5	Oak
150	14.0	26.5	Jack Pine
150	4.0	20.0	Oak
150	5.2	14.5	Oak
170	17.4	48.0	Jack Pine
180	8.8	6.0	Misc. Deciduous
200	12.5	27.0	Jack Pine
200	18.3	40.5	Jack Pine
205	14.9	21.0	Jack Pine
210	13.1	26.0	Jack Pine
210	13.4	16.5	Jack Pine
220	3.0	6.0	Jack Pine
224	13.4	23.5	Jack Pine
224	14.0	19.5	Jack Pine
225	8.2	31.0	Jack Pine
225	18.0	26.0	Jack Pine
225	3.0	6.0	Oak
225	3.0	9.0	Oak
227	15.8	20.0	Jack Pine
227	7.3	23.5	Oak
230	5.5	13.5	Oak
235	17.4	32.0	Oak
248	18.3	19.0	Dead J. Pine
257	4.6	29.0	Jack Pine
270	18.0	30.5	Jack Pine
275	15.2	26.0	Jack Pine
278	15.2	21.5	Jack Pine
280	17.7	27.5	Jack Pine

TABLE B19 (continued)

HEADING, DISTANCE, AND DIAMETER DATA FOR DENSE JACK PINE STANDS

Site 2 (concluded)

Heading	Distance (m)	Diameter (cm)	Species
283	11.0	26.0	Jack Pine
285	11.9	20.5	Jack Pine
288	10.4	25.0	Jack Pine
295	12.8	27.5	Jack Pine
300	4.9	8.5	Aspen
302	16.8	29.0	Aspen
307	17.4	29.0	Jack Pine
310	15.8	11.0	Aspen
310	10.1	13.5	Oak
310	10.1	17.0	Oak
320	8.5	8.0	Aspen
325	11.3	14.0	Aspen
330	12.8	11.0	Aspen
340	18.3	16.0	Jack Pine
340	14.3	6.0	Oak
342	7.9	14.5	Aspen
345	6.4	6.0	Jack Pine
345	6.7	5.0	Jack Pine
345	11.6	155.0	Jack Pine
345	5.5	30.0	Jack Pine
345	18.9	28.0	Aspen
345	18.9	29.0	Aspen
345	5.8	6.0	Oak
350	4.9	4.0	Aspen

TABLE B19 (continued)

HEADING, DISTANCE, AND DIAMETER DATA FOR DENSE JACK PINE STANDS

Site 3

Heading	Distance (m)	Diameter (cm)	Species
5	3.7	21.0	Jack Pine
5	6.1	20.0	Jack Pine
10	10.4	20.5	Jack Pine
10	15.8	23.5	Jack Pine
20	3.7	11.0	D. Jack Pine
25	4.9	10.0	D. Jack Pine
25	16.5	23.0	D. Jack Pine
30	6.4	22.5	Jack Pine
30	2.4	18.0	Jack Pine
35	7.3	13.5	Jack Pine
35	5.8	15.5	D. Jack Pine
35	7.0	11.0	D. Jack Pine
40	14.3	24.0	Jack Pine
45	9.4	18.0	Jack Pine
45	10.4	22.0	Jack Pine
45	11.6	19.0	Jack Pine
45	15.8	20.0	D. Jack Pine
50	10.1	23.0	Jack Pine
50	15.2	18.0	D. Jack Pine
50	14.9	10.3	D. Jack Pine
55	3.7	9.0	Jack Pine
55	26.5	19.0	D. Jack Pine
60	25.0	16.0	Jack Pine
60	25.3	12.0	Jack Pine
60	25.9	19.0	Jack Pine
60	14.9	21.0	Jack Pine
60	7.9	19.5	Jack Pine
60	26.8	12.0	D. Jack Pine
60	25.0	18.0	D. Jack Pine
65	24.4	16.0	Jack Pine
65	16.8	17.0	Jack Pine
65	6.1	11.0	D. Jack Pine
70	43.3	20.0	Jack Pine
70	19.5	16.0	D. Jack Pine
72	42.4	25.0	Jack Pine
75	21.0	11.0	D. Jack Pine
75	39.0	11.0	D. Jack Pine
75	45.7	28.0	Jack Pine
75	43.0	19.0	Jack Pine
75	12.8	18.0	Jack Pine

TABLE B19 (continued)

HEADING, DISTANCE, AND DIAMETER DATA FOR DENSE JACK PINE STANDS

Site 3 (continued)

Heading	Distance (m)	Diameter (cm)	Species
75	15.5	25.5	Jack Pine
78	43.9	16.5	Jack Pine
80	8.8	11.0	D. Jack Pine
80	20.4	21.0	D. Jack Pine
80	29.3	20.0	D. Jack Pine
80	16.2	11.5	Jack Pine
80	14.3	14.0	Jack Pine
80	5.2	17.0	Jack Pine
85	42.4	13.0	D. Jack Pine
85	42.1	11.0	D. Jack Pine
85	39.0	11.0	D. Jack Pine
85	44.5	10.0	D. Jack Pine
85	46.6	22.0	Jack Pine
85	15.8	22.0	Jack Pine
90	14.0	12.0	D. Jack Pine
90	39.0	10.0	D. Jack Pine
90	35.7	11.0	D. Jack Pine
90	44.5	11.0	Oak
90	36.0	10.0	D. Jack Pine
90	33.5	9.5	D. Jack Pine
90	29.3	23.0	D. Jack Pine
90	39.3	32.0	Jack Pine
90 to 100	49.1	18.5	D. Jack Pine
90 to 100	49.1	19.0	D. Jack Pine
90 to 100	15.2	20.5	D. Jack Pine
90 to 100	41.2	21.5	D. Jack Pine
90 to 100	5.8	17.0	Jack Pine
90 to 100	8.2	15.0	Jack Pine
90 to 100	10.7	6.5	Jack Pine
90 to 100	11.0	18.5	Jack Pine
90 to 100	13.1	19.0	Jack Pine
90 to 100	15.2	17.0	Jack Pine
90 to 100	17.4	20.0	Jack Pine
90 to 100	24.7	15.0	Jack Pine
90 to 100	24.7	15.5	Jack Pine
90 to 100	27.4	23.5	Jack Pine
90 to 100	28.7	26.5	Jack Pine
90 to 100	32.6	30.0	Jack Pine
90 to 100	36.6	32.0	Jack Pine
90 to 100	45.1	21.5	Jack Pine
90 to 100	45.1	24.0	Jack Pine
90 to 100	45.1	18.0	Jack Pine

TABLE B19 (continued)

HEADING, DISTANCE, AND DIAMETER DATA FOR DENSE JACK PINE STANDS

Site 3 (continued)

Heading	Distance (m)	Diameter (cm)	Species
90 to 100	45.7	22.5	Jack Pine
90 to 100	46.9	16.5	Jack Pine
90 to 100	49.1	17.0	Jack Pine
100	6.7	5.0	Misc. Deciduous
100	27.1	19.5	D. Jack Pine
100 to 110	26.8	14.5	Birch
100 to 110	43.9	28.0	D. Jack Pine
100 to 110	42.7	27.0	D. Jack Pine
100 to 110	12.8	11.0	D. Jack Pine
100 to 110	12.8	17.0	D. Jack Pine
100 to 110	12.2	9.0	D. Jack Pine
100 to 110	25.3	20.0	D. Jack Pine
100 to 110	25.6	18.0	D. Jack Pine
100 to 110	26.5	25.0	Jack Pine
100 to 110	27.4	20.0	Jack Pine
100 to 110	48.8	21.0	Jack Pine
100 to 110	50.3	28.0	Jack Pine
100 to 110	32.9	21.5	Jack Pine
100 to 110	33.2	21.5	Jack Pine
100 to 110	36.6	18.5	Jack Pine
100 to 110	37.5	19.5	Jack Pine
100 to 110	32.6	12.5	Maple
100 to 110	49.1	9.0	Oak
110 tp 120	32.6	22.0	Jack Pine
110 tp 120	32.3	19.5	Jack Pine
110 tp 120	15.2	20.0	Jack Pine
110 tp 120	11.9	21.0	Jack Pine
110 tp 120	10.7	18.0	Jack Pine
110 tp 120	3.4	17.0	Jack Pine
120 to 130	23.5	6.0	Birch
120 to 130	29.0	20.0	Jack Pine
120 to 130	27.1	15.0	Jack Pine
120 to 130	27.1	29.0	Jack Pine
120 to 130	14.6	30.0	Jack Pine
120 to 130	14.3	27.5	Jack Pine
120 to 130	10.4	23.0	Jack Pine
120 to 130	7.3	24.5	Jack Pine
120 to 130	22.3	5.0	Misc. Deciduous
120 to 130	26.2	17.5	Jack Pine
130 to 140	5.2	18.5	D. Jack Pine

TABLE B19 (continued)

HEADING, DISTANCE, AND DIAMETER DATA FOR DENSE JACK PINE STANDS

Site 3 (continued)

Heading	Distance (m)	Diameter (cm)	Species
145	25.9	18.5	Jack Pine
145	23.2	19.0	Jack Pine
145	18.3	19.5	Jack Pine
147	20.4	26.5	Jack Pine
148	8.5	13.5	Jack Pine
150	11.3	22.0	Jack Pine
150	9.8	13.0	Jack Pine
150	8.8	9.5	D. Jack Pine
150	22.9	11.5	D. Jack Pine
155	13.1	17.0	Jack Pine
155	6.7	16.5	Jack Pine
158	15.8	17.0	Jack Pine
160	23.2	14.5	Jack Pine
160	18.9	12.0	Jack Pine
160	17.1	23.5	Jack Pine
160	15.2	18.5	Jack Pine
163	23.8	13.0	Jack Pine
165	24.4	19.5	Jack Pine
173	18.3	17.0	Jack Pine
175	18.3	18.5	Jack Pine
175	15.8	11.5	Jack Pine
175	14.0	17.0	Jack Pine
175	14.0	17.0	Jack Pine
175	7.9	14.5	Jack Pine
180	17.7	21.0	Jack Pine
180	5.5	10.0	Jack Pine
185	18.3	10.0	Jack Pine
185	15.8	15.0	Jack Pine
185	11.9	14.0	Jack Pine
185	10.4	14.5	Jack Pine
190	17.4	15.0	Jack Pine
195	14.9	23.0	Jack Pine
195	13.4	20.0	Jack Pine
195	12.2	18.0	Jack Pine
200	8.5	21.5	Jack Pine
205	12.8	25.0	Jack Pine
205	6.7	20.5	Jack Pine
210	14.3	14.0	Jack Pine
210	11.6	24.0	Jack Pine
210	8.2	20.5	Jack Pine

TABLE B19 (continued)

HEADING, DISTANCE, AND DIAMETER DATA FOR DENSE JACK PINE STANDS

Site 3 (continued)

Heading	Distance (m)	Diameter (cm)	Species
215	8.5	10.0	D. Jack Pine
220	10.7	17.0	Jack Pine
225	18.3	10.0	D. Jack Pine
225	17.7	18.0	D. Jack Pine
230	9.8	12.0	Jack Pine
230	18.3	15.5	Jack Pine
230	11.9	17.0	Jack Pine
230	18.3	8.0	D. Jack Pine
235	13.7	18.5	Jack Pine
235	10.7	22.0	Jack Pine
250	6.1	16.0	Birch
250	13.4	26.0	Jack Pine
255	6.1	30.0	Birch
255	12.8	25.0	Jack Pine
255	1.5	18.0	Jack Pine
280	18.3	28.0	Jack Pine
280	18.3	20.0	D. Jack Pine
285	15.2	16.0	Jack Pine
290	8.8	9.0	Jack Pine
290	5.2	20.0	Jack Pine
290	16.8	15.0	Jack Pine
290	13.7	19.5	Jack Pine
295	15.2	23.0	Jack Pine
300	9.1	11.5	D. Jack Pine
305	15.5	15.0	Jack Pine
305	10.1	13.5	Jack Pine
305	8.5	21.5	Jack Pine
305	15.8	21.0	D. Jack Pine
315	3.4	11.5	D. Jack Pine
320	4.0	12.0	Jack Pine
320	2.4	11.0	D. Jack Pine
320	15.8	9.0	D. Jack Pine
325	13.1	21.0	Jack Pine
330	10.7	20.0	Jack Pine
330	7.9	20.0	Jack Pine
330	15.8	17.0	D. Jack Pine
330	14.0	8.5	D. Jack Pine
330	7.9	10.0	D. Jack Pine
330	7.0	14.5	D. Jack Pine

TABLE B19 (continued)

HEADING, DISTANCE, AND DIAMETER DATA FOR DENSE JACK PINE STANDS

Site 3 (concluded)

Heading	Distance (m)	Diameter (cm)	Species
335	10.1	14.0	D. Jack Pine
335	13.7	22.0	D. Jack Pine
340	16.5	24.0	Oak
345	7.0	13.0	Aspen
345	10.4	14.5	Jack Pine
345	10.4	10.0	D. Jack Pine
350	13.1	14.0	Jack Pine
350	11.6	23.5	Jack Pine
350	18.0	11.0	D. Jack Pine
350	17.4	19.0	D. Jack Pine
355	11.6	16.5	Jack Pine
355	14.6	21.0	Jack Pine
360	13.1	14.0	Jack Pine
360	17.4	9.0	D. Jack Pine

TABLE B19 (continued)

HEADING, DISTANCE, AND DIAMETER DATA FOR DENSE JACK PINE STANDS

Site 4

Heading	Distance (m)	Diameter (cm)	Species
12	3.0	8.0	Aspen
15	11.9	14.0	Aspen
24	20.4	23.5	Jack Pine
25	19.5	17.5	Aspen
25	16.2	28.0	Dead Aspen
27	21.3	14.5	Jack Pine
35	15.5	20.5	Aspen
35	23.8	24.0	Dead J. Pine
38	8.8	23.5	Jack Pine
38	18.3	9.5	Jack Pine
39	19.2	15.0	Jack Pine
40	11.6	30.5	Jack Pine
40	5.5	17.0	Jack Pine
40	21.9	29.0	Jack Pine
42	7.0	25.0	Jack Pine
42	25.3	25.0	Jack Pine
45	9.4	10.5	Dead J. Pine
50	20.4	23.5	Jack Pine
50	25.0	18.5	Jack Pine
55	16.2	18.0	Jack Pine
58	29.6	22.5	Jack Pine
60	31.4	14.0	Oak
60	10.1	18.0	Jack Pine
60	14.9	12.5	Jack Pine
65	25.3	25.5	Dead J. Pine
66	8.5	18.0	Jack Pine
67	20.7	10.0	Dead J. Pine
68	7.9	18.0	Jack Pine
68	22.3	18.0	Jack Pine
69	18.9	20.5	Dead J. Pine
70	15.2	13.0	Jack Pine
70	16.8	19.5	Jack Pine
70	24.1	17.5	Jack Pine
70	34.4	19.5	Jack Pine
70	17.1	10.5	Dead J. Pine
72	30.2	15.0	Jack Pine
74	30.8	23.0	Jack Pine
75	15.2	14.5	Jack Pine
75	21.0	19.5	Jack Pine
75	36.6	24.0	Jack Pine
75	24.1	17.5	Dead J. Pine

TABLE B19 (continued)

HEADING, DISTANCE, AND DIAMETER DATA FOR DENSE JACK PINE STANDS

Site 4 (continued)

Heading	Distance (m)	Diameter (cm)	Species
78	29.0	29.0	Jack Pine
78	9.1	10.5	Dead J. Pine
80	6.7	24.0	Jack Pine
80	12.8	22.0	Jack Pine
80	21.0	15.5	Jack Pine
80	32.6	25.5	Jack Pine
80	36.3	19.5	Jack Pine
80	47.2	23.5	Jack Pine
80	6.4	14.0	Dead J. Pine
82	17.1	6.5	Maple
83	25.3	17.0	Dead J. Pine
84	22.6	15.0	Aspen
85	15.8	13.0	Jack Pine
85	19.5	22.0	Jack Pine
88	24.7	10.5	Jack Pine
88	39.3	14.5	Jack Pine
90	24.1	27.0	Jack Pine
90	41.5	22.0	Jack Pine
90	15.8	21.0	Jack Pine
92	35.7	13.0	Dead J. Pine
93	20.4	16.0	Jack Pine
95	7.3	8.0	Jack Pine
95	12.2	20.0	Jack Pine
95	19.8	11.0	Jack Pine
95	34.4	24.0	Jack Pine
95	44.5	19.5	Jack Pine
95	38.4	16.0	Oak
95	41.8	22.0	Oak
97	39.3	16.0	Oak
100	32.3	23.0	Jack Pine
100	36.5	14.0	Jack Pine
100	39.0	10.0	Jack Pine
100	45.7	22.5	Jack Pine
100	45.4	14.5	Jack Pine
100	43.6	11.0	Dead J. Pine
100	45.1	10.0	Dead J. Pine
103	45.7	24.5	Jack Pine
105	4.0	12.5	Jack Pine
105	23.2	6.0	Jack Pine
105	23.5	13.0	Jack Pine
105	35.4	18.0	Jack Pine

TABLE B19 (continued)

HEADING, DISTANCE, AND DIAMETER DATA FOR DENSE JACK PINE STANDS

Site 4 (continued)

Heading	Distance (m)	Diameter (cm)	Species
105	35.4	14.0	Jack Pine
105	39.6	25.0	Jack Pine
105	42.1	21.5	Jack Pine
105	47.9	25.5	Jack Pine
106	39.6	16.0	Jack Pine
107	36.9	13.5	Jack Pine
110	16.8	22.0	Jack Pine
110	34.7	31.5	Jack Pine
111	37.5	11.0	Jack Pine
112	11.6	24.5	Jack Pine
112	20.7	19.0	Dead J. Pine
113	36.3	22.0	Jack Pine
115	34.1	16.0	Dead J. Pine
117	36.0	16.5	Jack Pine
117	37.5	14.0	Jack Pine
117	37.5	19.5	Jack Pine
118	19.5	17.5	Jack Pine
120	8.2	12.5	Jack Pine
120	23.8	22.0	Jack Pine
120	33.8	19.0	Jack Pine
120	18.6	24.0	Dead J. Pine
120	18.6	19.0	Dead J. Pine
120	22.6	18.0	Dead J. Pine
122	8.8	16.5	Jack Pine
122	29.0	25.0	Jack Pine
122	29.0	10.0	Jack Pine
122	33.5	15.0	Jack Pine
122	33.8	13.0	Jack Pine
122	38.4	21.0	Jack Pine
122	39.0	13.5	Jack Pine
123	35.4	22.0	Jack Pine
123	14.9	17.5	Dead J. Pine
125	2.1	22.5	Jack Pine
125	25.0	14.0	Jack Pine
125	29.6	10.0	Jack Pine
125	39.6	23.0	Jack Pine
125	39.6	17.5	Jack Pine
128	34.1	23.0	Oak
128	18.3	20.0	Jack Pine
128	38.4	13.0	Jack Pine
128	13.4	19.5	Dead J. Pine

TABLE B19 (continued)

HEADING, DISTANCE, AND DIAMETER DATA FOR DENSE JACK PINE STANDS

Site 4 (continued)

Heading	Distance (m)	Diameter (cm)	Species
130	3.7	23.5	Jack Pine
130	8.2	17.5	Jack Pine
130	30.5	23.0	Jack Pine
132	18.9	7.5	Jack Pine
132	16.5	8.0	Dead J. Pine
132	16.5	8.0	Dead J. Pine
132	18.9	7.5	Jack Pine
135	5.8	13.0	Jack Pine
135	5.8	13.0	Jack Pine
135	22.9	22.5	Dead J. Pine
140	19.5	12.5	Dead J. Pine
145	17.7	21.5	Jack Pine
145	13.7	11.5	Dead J. Pine
145	15.2	22.0	Dead J. Pine
146	6.7	8.0	Jack Pine
147	7.3	11.0	Dead J. Pine
150	7.3	17.0	Jack Pine
150	17.7	7.0	Jack Pine
150	18.3	11.5	Jack Pine
152	25.3	26.0	Jack Pine
152	16.8	6.5	Dead J. Pine
155	12.5	22.5	Jack Pine
157	20.1	16.0	Oak
158	16.2	26.0	Jack Pine
165	9.8	13.0	Jack Pine
165	10.1	20.5	Jack Pine
170	15.5	19.0	Jack Pine
172	14.0	14.0	Dead J. Pine
175	5.5	14.0	Jack Pine
175	12.2	14.0	Jack Pine
175	18.9	16.5	Jack Pine
188	14.9	10.0	Dead J. Pine
190	4.9	15.5	Jack Pine
195	19.2	14.5	Aspen
200	18.3	10.5	Aspen
210	17.4	19.5	Aspen
210	6.7	17.5	Jack Pine
210	7.0	7.0	Jack Pine
218	18.0	18.0	Oak
225	9.1	18.0	Jack Pine
230	6.7	8.5	Jack Pine
230	8.2	12.0	Jack Pine

TABLE B19 (continued)

HEADING, DISTANCE, AND DIAMETER DATA FOR DENSE JACK PINE STANDS

Site 4 (continued)

Heading	Distance (m)	Diameter (cm)	Species
230	4.0	12.0	Dead J. Pine
232	3.8	18.5	Jack Pine
234	6.4	11.5	Jack Pine
235	.9	15.5	Jack Pine
235	5.2	7.5	Dead J. Pine
240	4.9	11.5	Jack Pine
236	6.7	7.0	Dead J. Pine
240	9.4	15.0	Jack Pine
245	9.1	11.0	Jack Pine
245	6.7	9.5	Dead J. Pine
248	16.8	21.0	Aspen
250	6.7	17.0	Jack Pine
260	16.5	9.5	Oak
260	16.5	13.0	Oak
260	5.5	17.5	Jack Pine
260	9.8	7.0	Jack Pine
264	3.4	14.5	Jack Pine
265	8.5	15.0	Jack Pine
266	3.4	10.5	Dead J. Pine
270	17.4	9.0	Aspen
270	10.7	21.5	Jack Pine
272	10.7	11.0	Jack Pine
275	11.6	6.5	Jack Pine
278	12.2	8.0	Dead J. Pine
280	11.6	18.0	Jack Pine
282	5.8	15.0	Jack Pine
282	11.3	9.5	Jack Pine
285	7.9	15.5	Jack Pine
285	9.4	13.0	Jack Pine
290	6.7	16.5	Jack Pine
295	8.2	10.0	Jack Pine
295	18.3	23.0	Jack Pine
308	6.1	20.0	Jack Pine
310	1.2	12.5	Jack Pine
315	8.8	19.5	Jack Pine
318	9.8	13.0	Jack Pine
330	10.1	19.5	Jack Pine
330	9.8	6.0	Jack Pine
332	13.1	23.5	Jack Pine
335	17.1	16.5	Jack Pine
338	14.9	12.0	Jack Pine
340	16.2	15.5	Jack Pine

TABLE B19 (continued)

HEADING, DISTANCE, AND DIAMETER DATA FOR DENSE JACK PINE STANDS

Site 4 (concluded)

345	5.5	13.5	Jack Pine
345	7.6	12.5	Jack Pine
355	8.5	7.0	Aspen
355	9.4	17.0	Aspen
355	11.3	12.5	Jack Pine
360	3.0	17.5	Aspen
360	11.3	18.0	Aspen
360	12.5	22.0	Dead Aspen
360	5.5	15.0	Jack Pine
365	16.2	24.0	Jack Pine

TABLE B19 (continued)

HEADING, DISTANCE, AND DIAMETER DATA FOR DENSE JACK PINE STANDS

Site 5

Heading	Distance (m)	Diameter (cm)	Species
0	14.9	20.0	Jack Pine
0	14.0	23.5	Jack Pine
2	8.5	12.5	Jack Pine
5	15.8	14.0	Jack Pine
15	10.4	14.5	Jack Pine
15	7.9	24.0	Jack Pine
17	7.6	16.5	Jack Pine
18	6.4	19.5	Jack Pine
20	9.8	20.5	Jack Pine
23	16.8	40.0	Oak
28	11.6	17.5	Jack Pine
32	10.4	11.0	Jack Pine
32	10.1	23.5	Jack Pine
33	9.8	10.0	Dead J. Pine
38	7.9	22.5	Jack Pine
42	8.8	16.5	Jack Pine
60	18.3	12.5	Dead Aspen
60	18.0	25.0	Jack Pine
62	14.3	19.0	Jack Pine
68	11.6	10.0	Aspen
75	41.1	12.0	Aspen
75	40.2	15.0	Aspen
75	39.0	22.0	Aspen
75	43.9	29.0	Jack Pine
75	45.7	20.0	Jack Pine
75	45.1	25.0	Jack Pine
80	5.2	25.0	Jack Pine
80	40.5	27.0	Jack Pine
82	44.5	10.0	Jack Pine
83	39.9	21.5	Jack Pine
85	40.2	17.0	Aspen
87	39.9	8.0	Jack Pine
87	40.2	27.0	Jack Pine
90	36.3	20.0	Aspen
90	13.1	28.0	Jack Pine
90	30.8	19.0	Jack Pine
93	43.9	15.0	Jack Pine
93	45.7	27.0	Jack Pine
93	44.2	14.0	Jack Pine
93	42.1	13.0	Dead J. Pine
95	44.5	14.0	Jack Pine

TABLE B19 (continued)

HEADING, DISTANCE, AND DIAMETER DATA FOR DENSE JACK PINE STANDS

Site 5 (continued)

Heading	Distance (m)	Diameter (cm)	Species
96	45.7	17.0	Aspen
97	40.5	33.0	Jack Pine
97	40.5	11.0	Jack Pine
100	35.1	19.5	Jack Pine
102	45.4	23.0	Jack Pine
105	40.8	11.0	Aspen
105	41.5	17.0	Aspen
105	30.5	20.5	Jack Pine
107	5.8	19.5	Jack Pine
135	8.5	31.0	Jack Pine
142	14.6	33.0	Jack Pine
145	18.3	19.5	Jack Pine
145	18.3	20.0	Jack Pine
150	18.9	21.5	Jack Pine
155	18.6	22.5	Jack Pine
155	18.3	5.0	Jack Pine
160	16.5	11.0	Jack Pine
162	18.3	13.5	Jack Pine
165	12.2	22.5	Jack Pine
167	11.3	22.5	Jack Pine
168	12.2	14.5	Jack Pine
170	4.9	27.0	Jack Pine
170	11.0	21.0	Jack Pine
175	11.3	22.5	Jack Pine
175	11.9	21.5	Jack Pine
182	11.3	18.0	Jack Pine
185	18.3	19.0	Jack Pine
204	10.7	10.5	Jack Pine
205	6.1	30.0	Jack Pine
205	10.7	18.0	Jack Pine
207	12.5	9.5	Jack Pine
210	14.3	29.0	Jack Pine
210	15.5	18.0	Jack Pine
225	16.5	8.0	Jack Pine
225	17.4	22.0	Jack Pine
225	17.1	23.0	Jack Pine
225	12.2	25.0	Jack Pine
227	16.2	24.5	Jack Pine
228	5.8	13.5	Jack Pine
232	16.2	8.0	Jack Pine
235	17.7	11.0	Jack Pine

TABLE B19 (concluded)

HEADING, DISTANCE, AND DIAMETER DATA FOR DENSE JACK PINE STANDS

Site 5 (concluded)

Heading	Distance (m)	Diameter (cm)	Species
237	4.3	26.0	Jack Pine
240	6.4	25.5	Jack Pine
240	12.5	24.0	Jack Pine
247	5.5	17.0	Jack Pine
247	12.2	27.5	Jack Pine
250	4.6	24.0	Jack Pine
270	20.7	28.0	Jack Pine
270	19.2	38.5	Dead J. Pine
293	8.2	27.5	Jack Pine
300	4.9	27.0	Jack Pine
312	4.9	18.0	Jack Pine
312	6.1	24.5	Jack Pine
315	7.9	24.0	Jack Pine
322	15.8	32.5	Jack Pine
325	13.7	30.5	Jack Pine
330	18.9	57.5	Oak
335	7.3	21.0	Jack Pine
352	15.8	21.0	Jack Pine

APPENDIX C

TREE DIELECTRIC DATA

This appendix contains a summary of all data collected to characterize the dielectrics of the jack pine and aspen trees contained within the ALP test site. An asterisk (*) following an entry indicates that this data was not used to calculate the average value for that entry.

With respect to measurement of a the dielectric profile of a tree, several different measurements were made at the cambium layer. Where two cambium samples our indicated, the first measurement was made at the outside of the cambium layer, while the second measurement was made at the inside of this layer. With aspen trees, where the cambium layer was not as clearly separable as with pines, three measurements were made: one at the outside, one in the middle, and one at the inside.

TABLE C1
JACK PINE BARK DIELECTRIC MEASUREMENTS

	e'			e"			Average		Std Dev	
Sample	1	2	3	1	2	3	e'	e"	e'	e"
X-BAND										
A	1.78	1.82	1.82	.13	.13	.13	1.81	.13	.02	.00
B	2.09	1.98	1.94	.09	.09	.09	2.00	.09	.07	.00
C	1.82	1.82	1.82	.13	.13	.13	1.82	.13	.00	.00
D	1.82	2.09	2.17	.06	.13	.13	2.03	.11	.15	.03
E	1.94	2.05	1.74	.19	.19	.13	1.91	.17	.13	.03
F	1.98	2.05	2.09	.20	.20	.20	2.04	.20	.05	.00
G	2.41	1.86	1.82	.33	.26	.20	2.03	.26	.27	.05
H	2.13	1.82	1.82	.20	.20	.20	1.92	.20	.15	.00
I	2.41	2.41	2.41	.33	.33	.33	2.41	.33	.00	.00
J	1.82	2.05	2.13	.20	.20	.20	2.00	.20	.13	.00
						Total	2.00	.20	.18	.07
L-BAND										
A							1.80	.36		
B							1.80	.00		
C							1.80	.00		
D							2.30	.12		
E							1.20	.00		
F							1.80	.00		
G							1.30	.00		
H							1.00	.00		
I							1.00	.00		
J							1.00	1.12		
						Total	1.50	.16	.43	.34

TABLE C2
JACK PINE CAMBIUM DIELECTRIC PROFILES

X-BAND

Sample	e' 1	e' 2	e' 3	e" 1	e" 2	e" 3	Average e'	Average e"	Std Dev e'	Std Dev e"
1 October 1989 - AM Measurements										
A	20.42	19.82	20.98	12.87	13.38	14.19	20.40	13.48	.48	.54
B	20.86	15.14	20.86	12.77	8.34	12.77	18.96	11.29	2.70	2.09
C	24.12	25.44	25.96	14.06	16.45	16.00	25.17	15.50	.78	1.04
D	23.32	25.28	25.51	16.50	16.26	16.54	24.71	16.44	.98	.12
E	19.88	20.59	22.39	13.08	14.19	14.44	20.95	13.90	1.06	.59
F	21.78	17.93	15.40	13.81	12.29	10.08	18.37	12.06	2.62	1.53
G	22.51	17.72	20.15	14.32	11.65	13.52	20.13	13.16	1.96	1.12
H	15.55	10.74	13.55	9.49	5.34	8.02	13.28	7.61	1.97	1.72
I	17.12	23.26	23.70	10.92	14.74	15.21	21.36	13.62	3.00	1.92
J	23.53	22.11	20.37	15.50	15.74	14.16	22.00	15.13	1.29	.70
K	20.20	20.96	21.37	12.34	12.66	13.03	20.84	12.68	.48	.28
L	22.98	22.05	20.98	15.55	15.40	14.19	22.00	15.05	.82	.61
M	16.31	19.05	20.11	10.09	12.17	12.45	18.49	11.57	1.60	1.05
N	19.26	22.94	24.05	12.18	15.04	15.34	22.08	14.18	2.05	1.42
O	21.85	18.45	17.39	13.88	11.81	11.25	19.23	12.31	1.90	1.13
P	18.24	14.86	16.20	11.35	8.87	9.66	16.43	9.96	1.39	1.03
Q	14.91	17.17	13.87	8.90	11.08	7.45	15.32	9.14	1.38	1.49
R	21.73	24.02	23.63	15.03	15.80	15.84	23.13	15.56	1.00	.37
S	17.01	17.25	18.32	11.51	12.30	12.64	17.53	12.15	.57	.47
T	19.59	23.25	24.83	11.52	14.47	14.77	22.55	13.59	2.20	1.47
						Total	20.15	12.92	3.39	2.49
2 October 1989 - AM Measurements										
A	24.06	24.34	25.09	17.62	18.70	19.25	24.50	18.53	.44	.68
B	30.59	29.53	32.57	19.49	24.92	22.91	30.90	22.44	1.26	2.24
C	21.54	19.99	23.32	14.81	12.83	14.55	21.62	14.06	1.36	.88
D	18.71	18.37	19.24	13.56	13.56	14.38	18.78	13.83	.35	.39
E	19.28	21.99	21.18	14.98	17.80	16.55	20.82	16.44	1.14	1.15
F	14.04	16.28	15.70	10.80	11.76	11.56	15.34	11.37	.95	.42
G	15.83	17.16	13.72	10.99	13.70	9.36	15.57	11.35	1.42	1.79
H	21.83	18.63	20.45	17.54	15.48	16.05	20.30	16.36	1.31	.87
I	15.31	17.63	20.12	10.86	14.23	13.91	17.69	13.00	1.97	1.52
J	19.23	18.23	19.20	13.73	13.07	14.08	18.89	13.62	.47	.42
K	23.56	22.81	24.36	16.32	18.15	18.69	23.57	17.73	.63	1.02
L	28.72	26.39	25.13	21.07	20.34	19.67	26.75	20.36	1.49	.57
M	17.56	16.80	19.17	13.42	12.98	14.44	17.84	13.61	.99	.61
						Total	20.97	15.59	4.47	3.46

TABLE C2 (continued)
JACK PINE CAMBIUM DIELECTRIC PROFILES

X-BAND

Sample	e' 1	e' 2	e' 3	e" 1	e" 2	e" 3	Average e'	Average e"	Std Dev e'	Std Dev e"
2 October 1989 - PM Measurements										
A	23.88	20.93	21.78	16.49	16.73	15.37	22.20	16.20	1.24	.59
B	15.49	14.05	15.21	10.27	9.99	11.28	14.92	10.51	.62	.55
C	17.15	16.64	17.37	14.99	13.97	14.08	17.05	14.35	.31	.46
D	19.61	18.30	19.47	17.04	14.35	16.82	19.12	16.07	.59	1.22
E	20.73	19.80	19.08	16.18	16.81	15.76	19.87	16.25	.67	.43
F	17.24	18.65	20.18	13.42	15.47	17.84	18.69	15.58	1.20	1.80
G	18.24	17.54	15.39	2.08	1.88	2.85	17.06	2.27	1.21	.42
H	21.30	23.12	23.53	17.28	19.90	19.95	22.65	19.04	.97	1.25
I	20.43	18.78	19.27	14.69	16.55	15.83	19.49	15.69	.69	.77
J	18.90	16.35	17.85	15.08	13.24	13.84	17.70	14.05	1.05	.77
K	21.31	23.37	23.53	18.19	19.25	20.35	22.74	19.26	1.01	.88
L	16.41	11.80	13.78	14.69	10.23	12.18	14.00	12.37	1.89	1.83
M	17.95	14.28	16.00	13.44	10.56	11.89	16.08	11.97	1.50	1.18
N	20.83	20.95	23.46	16.57	15.79	18.41	21.75	16.92	1.21	1.10
O	17.87	18.77	18.77	15.18	15.98	15.98	18.47	15.71	.42	.38
P	22.03	24.46	24.28	17.04	18.48	17.61	23.59	17.71	1.11	.59
Q	20.07	19.74	16.87	14.65	14.27	13.77	18.89	14.23	1.44	.36
R	12.09	13.57	14.92	8.50	9.29	9.71	13.53	9.17	1.15	.50
						Total	19.07	14.30	2.94	4.03

C-BAND

Sample	e' 1	e' 2	e' 3	e" 1	e" 2	e" 3	Average e'	Average e"	Std Dev e'	Std Dev e"
2 October 1989 - PM Data										
A	34.04	35.72	35.24	10.22	10.84	13.13	35.00	11.39	.71	1.25
B	26.72	29.99	28.60	10.93	11.99	10.53	28.44	11.15	1.34	.62
C	25.65	27.31	27.97	9.01	9.28	9.50	26.98	9.26	.98	.20
D	26.82	30.53	31.38	9.31	10.31	10.63	29.58	10.08	1.98	.56
E	29.30	30.82	30.70	9.66	9.89	9.85	30.27	9.80	.69	.10
F	26.27	28.64	29.76	8.36	9.36	9.46	28.22	9.23	1.46	.26
G	19.85	23.19	22.78	7.67	9.26	9.60	21.94	8.85	1.49	.84
H	31.00	31.93	31.64	9.36	9.05	8.65	31.52	9.02	.39	.29
I	27.70	29.22	29.93	8.00	8.71	8.93	28.95	8.55	.93	.40
J	21.46	26.60	27.65	9.04	8.90	8.96	25.24	8.97	2.71	.06
K	23.53	24.96	24.04	7.73	8.36	6.95	24.17	7.68	.59	.58
L	26.06	27.92	28.77	11.40	12.20	12.90	27.58	12.17	1.13	.61
M	26.97	29.43	30.72	9.57	10.74	11.25	29.04	10.52	1.55	.70
N	24.67	25.85	25.85	10.58	11.03	11.03	25.46	10.88	.56	.21
O	18.85	20.58	21.95	6.55	6.91	7.22	20.46	6.89	1.27	.28
P	24.85	27.78	27.78	7.96	8.55	8.55	26.80	8.35	1.38	.27
Q	21.13	21.95	22.80	5.56	7.19	7.39	21.96	6.71	.68	.82
R	15.45	18.53	20.11	4.24	7.21	7.37	18.03	6.27	1.94	1.44
						Total	26.65	9.21	4.29	1.74

TABLE C2 (continued)
JACK PINE CAMBIUM DIELECTRIC PROFILES

L-BAND

Sample	e' 1	e' 2	e' 3	e" 1	e" 2	e" 3	Average e'	Average e"	Std Dev e'	Std Dev e"
1 October 1989 - AM Data										
A							19.80	4.25		
B							25.70	5.31		
C							26.70	6.00		
D							27.20	6.16		
E							26.20	5.64		
F							21.50	4.88		
G							25.30	5.37		
H							23.50	5.50		
I							18.20	4.20		
J							26.50	6.09		
K							25.70	5.66		
L							26.50	6.10		
M							29.40	6.72		
N							23.10	5.94		
O							21.00	4.41		
P							18.10	4.60		
Q							24.40	5.64		
R							15.30	3.14		
S							24.90	6.19		
T							22.60	5.90		
						Total	23.61	5.39	3.54	.86
2 October 1989 - AM Data										
A	21.40	22.13	19.25	7.07	6.75	6.68	20.92	6.83	1.22	.17
B	27.86	24.96	21.40	9.81	8.97	6.77	24.74	8.52	2.64	1.28
C	22.82	30.09	21.37	7.76	9.51	8.09	24.76	8.45	3.82	.76
D	27.13	33.01	34.50	9.75	11.12	11.58	31.54	10.81	3.18	.78
E	27.86	31.27	30.29	9.72	10.96	10.55	29.81	10.41	1.43	.51
F	18.55	19.98	18.55	6.09	6.12	5.77	19.03	5.99	.67	.16
G	24.21	28.59	29.59	9.52	10.05	9.74	27.46	9.77	2.33	.22
H	22.80	26.41	27.15	8.41	9.21	9.24	25.45	8.95	1.90	.38
I	17.12	23.55	25.71	6.03	7.81	8.55	22.12	7.46	3.65	1.06
K	30.81	33.77	33.77	10.10	10.97	10.97	32.79	10.68	1.40	.41
L	24.99	28.62	24.98	8.14	9.30	8.48	26.20	8.64	1.71	.49
M	19.26	22.60	20.69	6.29	7.00	6.63	20.85	6.64	1.37	.29
N	24.50	26.43	29.35	8.37	8.77	9.57	26.76	8.90	1.99	.50
O	14.07	20.69	24.04	4.36	6.32	7.36	19.60	6.01	4.14	1.25
P	20.67	31.58	25.72	7.28	9.67	8.07	25.99	8.34	4.46	1.00
Q	28.64	30.09	33.07	8.85	9.60	10.10	30.60	9.52	1.84	.51
R	19.26	18.55	21.40	6.07	6.05	7.07	19.74	6.40	1.21	.47
						Total	25.20	8.37	4.94	1.70

TABLE C2 (concluded)
JACK PINE CAMBIUM DIELECTRIC PROFILES

L-BAND

Sample	e' 1	e' 2	e' 3	e" 1	e" 2	e" 3	Average e'	Average e"	Std Dev e'	Std Dev e"
2 October 1989 - PM Data										
A	17.14	20.69	22.12	5.23	6.60	6.97	19.98	6.27	2.10	.75
B	30.31	30.83	32.27	10.12	9.77	10.96	31.14	10.28	.83	.50
C	31.55	30.06	30.80	10.38	10.31	10.35	30.80	10.35	.61	.03
D	18.55	19.98	19.97	5.93	6.29	6.62	19.50	6.28	.67	.28
E	25.46	28.88	26.68	8.53	9.02	8.58	27.01	8.71	1.41	.22
F	24.99	24.28	25.01	8.17	7.45	7.47	24.76	7.69	.34	.33
G	17.36	22.35	22.35	6.24	7.35	7.35	20.69	6.98	2.35	.52
H	17.84	18.56	18.56	5.62	5.31	5.64	18.32	5.52	.34	.15
I	23.29	29.09	23.53	8.11	9.75	8.47	25.30	8.78	2.68	.70
J	26.68	28.86	27.40	8.58	9.38	8.96	27.65	8.97	.91	.33
K	28.62	28.63	27.88	9.37	9.01	9.34	28.38	9.24	.35	.16
L	24.50	27.88	29.36	8.15	9.34	9.40	27.25	8.96	2.03	.57
M	25.22	30.08	29.34	8.52	9.80	9.76	28.21	9.36	2.14	.59
						Total	25.31	8.26	4.45	1.57

TABLE C3
DIELECTRIC PROFILES OF JACK PINE TREES

Sample	e' 1	e' 2	e' 3	e" 1	e" 2	e" 3	Average e'	Average e"	Std Dev e'	Std Dev e"
Tree 1 - X-band										
Bark	1.78	1.82	1.82	.13	.13	.13	1.81	.13	.02	.00
Cambium 1	20.42	19.82	20.98	12.87	13.38	14.19	20.40	13.48	.48	.54
Cambium 2	14.36	8.65	8.12	7.49	2.73	2.58	10.37	4.27	2.82	2.28
8 mm	2.83	5.07	5.24	.96	2.01	2.02	4.38	1.66	1.10	.50
20 mm	1.16	1.27	1.23	.13	.13	.13	1.22	.13	.05	.00
40 mm	5.07	5.27	5.48	2.16	2.09	2.10	5.27	2.12	.17	.03
60 mm	5.17	4.89	4.89	1.61	1.60	1.52	4.98	1.58	.13	.04
80 mm	3.66	3.54	3.34	1.33	1.32	1.25	3.51	1.30	.13	.04
Tree 1 - L-band										
Bark							1.80	.36		
Cambium 1							19.80	4.25		
Cambium 2							21.00	4.05		
8 mm							4.30	.72		
20 mm							7.90	1.81		
40 mm							8.90	2.11		
60 mm							7.10	1.45		
80 mm							4.80	1.20		
Tree 2 - X-band										
Bark	1.82	2.05	1.89	.84	.93	.93	1.92	.90	.10	.04
Cambium 1	22.81	25.04	23.73	19.92	20.44	19.45	23.86	19.94	.91	.40
Cambium 2	18.73	24.66	25.43	15.71	20.20	20.09	22.94	18.67	2.99	2.09
8 mm	1.12	1.62	1.94	.28	.16	.34	1.56	.26	.34	.08
30 mm	7.19	6.65	5.70	3.86	3.79	3.51	6.51	3.72	.62	.15
60 mm	5.42	6.03	5.66	2.39	2.52	2.41	5.70	2.44	.25	.05
Tree 2 C-band										
Bark	1.39	1.00	.81	.19	.09	.00	1.06	.10	.24	.08
Cambium 1	23.54	25.99	26.69	6.83	7.42	7.37	25.41	7.21	1.35	.26
Cambium 2	24.40	25.61	25.47	5.73	8.78	9.24	25.16	7.92	.54	1.55
8 mm	4.69	2.87	3.33	2.08	1.41	1.73	3.63	1.74	.77	.27
30 mm	6.94	6.47	6.47	2.04	2.03	2.03	6.63	2.04	.22	.01
60 mm	2.55	2.62	2.75	.40	.30	.50	2.64	.40	.08	.08
Tree 2 L-Band										
Bark	2.40	3.09	2.40	.83	.83	.55	2.63	.74	.33	.13
Cambium 1	22.12	24.99	26.44	6.95	8.01	8.39	24.52	7.78	1.80	.61
Cambium 2	35.86	36.84	38.38	10.45	10.81	10.90	37.36	10.72	.72	.20
8 mm	8.68	4.49	6.59	3.10	1.66	2.23	6.59	2.33	1.71	.59
30 mm	10.08	10.08	9.38	3.69	3.69	3.69	9.85	3.69	.33	.00
60 mm	5.89	5.89	5.89	2.23	2.04	2.14	5.89	2.14	.00	.08

TABLE C4
ASPEN BARK DIELECTRIC MEASUREMENTS

X-BAND

Sample	e' 1	e' 2	e' 3	e" 1	e" 2	e" 3	Average e'	Average e"	Std Dev e'	Std Dev e"
A	10.29	10.70	9.72	3.49	3.67	3.40	10.24	3.52	.40	.11
B	9.14	9.79	10.88	3.19	3.28	3.52	9.94	3.33	.72	.14
C	5.84	5.74	6.13	1.46	1.78	1.39	5.90	1.54	.17	.17
D	2.88	2.84	2.76	.54	.61	.68	2.82	.61	.05	.06
E	3.23	3.23	3.35	.61	.68	.72	3.27	.67	.06	.05
F	8.84	8.00	10.12	3.05	2.85	3.33	8.99	3.08	.87	.19
G	10.85	7.51	3.98	3.67	2.52	.87	7.45	2.35	2.81	1.15
H	6.87	5.40	4.14	1.86	1.00	1.05	5.47	1.30	1.12	.39
I	5.88	6.25	6.25	1.48	1.58	1.58	6.12	1.55	.18	.05
J	8.93	6.48	5.72	2.19	1.03	1.32	7.04	1.51	1.37	.49
K	9.45	5.89	5.27	2.55	1.20	.98	6.87	1.58	1.84	.69
L	9.21	9.98	11.17	2.62	2.91	3.30	10.12	2.94	.80	.28
M	3.47	3.94	3.94	.70	.93	.85	3.78	.83	.22	.09
N	10.77	10.02	10.59	2.91	3.67	3.76	10.46	3.45	.32	.38
O	6.50	6.59	6.55	1.59	1.51	1.51	6.55	1.54	.04	.04
P	11.70	12.52	10.47	3.79	3.71	2.93	11.56	3.47	.84	.39
Q	5.31	4.50	4.63	1.07	.83	.84	4.81	.91	.36	.11
R	5.12	4.39	5.08	.44	.29	.41	4.86	.38	.33	.06
S	6.03	5.28	3.87	.51	.72	.41	5.06	.55	.90	.13
T	3.71	3.23	2.64	.61	.33	.46	3.19	.47	.44	.11
						Total	6.73	2.80	1.78	1.17

C-BAND

Sample	e' 1	e' 2	e' 3	e" 1	e" 2	e" 3	Average e'	Average e"	Std Dev e'	Std Dev e"
F	4.51	4.31	5.10	.74	.63	.63	4.64	.67	.34	.05
H	4.71	5.50	4.71	.22	.11	.11	4.97	.15	.37	.05
I	7.09	8.10	8.10	1.09	1.69	1.69	7.76	1.49	.47	.28
J	7.50	8.32	8.12	.47	.48	.48	7.98	.47	.35	.00
K	9.00	9.84	10.05	1.14	1.15	1.24	9.63	1.18	.45	.04
L	8.84	10.09	9.88	1.99	2.16	2.07	9.60	2.07	.55	.07
M	1.97*	2.36	2.55	-.03*	.62	.59	2.46	.60	.10	.02
N	11.19	11.84	11.84	2.98	3.02	3.02	11.62	3.00	.31	.02
O	10.82	10.81	11.46	1.63	2.01	1.78	11.03	1.81	.31	.16
P	9.12	9.33	9.54	1.89	1.94	1.94	9.33	1.92	.17	.02
Q	9.74	9.60	10.59	2.13	2.00	2.04	9.98	2.06	.44	.06
R	9.12	9.33	9.13	1.85	1.86	1.61	9.19	1.77	.10	.12
S	6.09	6.09	8.10	1.06	1.29	1.49	6.76	1.28	.95	.17
T	8.91	8.51	7.49	1.94	1.69	1.66	8.30	1.76	.60	.13
						Total	8.23	2.41	1.47	.75

TABLE C4
ASPEN BARK DIELECTRIC MEASUREMENTS

L-BAND

	e'			e"			Average		Std Dev	
Sample	1	2	3	1	2	3	e'	e"	e'	e"
A	5.89	7.99	7.99	1.04	1.40	1.40	7.29	1.28	.99	.17
B	8.22	4.03	4.03	1.40	.35	.35	5.42	.70	1.98	.50
C	4.49	5.19	7.29	1.04	1.39	1.04	5.66	1.15	1.19	.16
D	5.19	5.89	5.89	1.04	1.04	1.04	5.66	1.04	.33	.00
E	1.70	1.70	1.23	.00	.00	.00	1.54	.00	.22	.00
F	1.93	1.93	1.93	.34	.34	.34	1.93	.34	.00	.00
G	3.79	3.79	4.26	.33	.33	.33	3.95	.33	.22	.00
H	7.29	7.29	6.12	1.34	1.68	1.00	6.90	1.34	.55	.28
I	5.89	4.49	3.79	1.00	.66	.33	4.72	.66	.87	.27
J	4.96	5.66	4.96	.66	.66	.66	5.19	.66	.33	.00
K	4.96	4.96	4.26	.66	.66	.33	4.72	.55	.33	.16
L	2.40	3.79	3.79	.65	.65	.99	3.33	.76	.66	.16
M	2.16	1.70	1.70	.32	.32	.32	1.85	.32	.22	.00
N	6.59	8.69	8.69	1.30	1.31	1.31	7.99	1.31	.99	.00
O	7.29	9.39	9.39	.96	1.29	1.29	8.69	1.18	.99	.15
P	6.59	6.82	6.59	1.27	1.27	1.27	6.67	1.2	.11	.00
Q	3.09	3.09	2.40	.63	.63	.63	2.86	.63	.33	.00
R	9.16	8.92	8.92	1.38	1.48	1.59	9.00	1.48	.11	.09
S	1.70	1.70	1.70	.31	.31	.31	1.70	.31	.00	.00
T	7.99	7.29	7.29	1.58	.94	1.58	7.52	1.37	.33	.30
						Total	5.00	.83	2.43	.47

TABLE C5
ASPEN CAMBIUM DIELECTRIC MEASUREMENTS

X-BAND

Sample	e' 1	e' 2	e' 3	e" 1	e" 2	e" 3	Average e'	Average e"	Std Dev e'	Std Dev e"
A1	6.16	5.23	5.92	2.45	2.16	2.26	5.77	2.29	.39	.12
A2	10.23	7.88	9.23	5.43	4.12	4.12	9.11	4.56	.96	.62
A3	6.90	6.79	6.83	2.58	2.42	2.49	6.84	2.50	.05	.07
B	8.94	10.35	9.48	4.22	5.49	5.15	9.59	4.96	.58	.54
C	11.11	17.69	17.52	7.06	11.33	11.20	15.44	9.87	3.06	1.98
D	18.12	18.60	9.16	12.19	11.98	3.01	15.30	9.06	4.34	4.28
E	7.99	9.90	10.26	5.00	6.09	6.47	9.38	5.85	1.00	.62
F	10.79	4.42	3.71	5.72	.81	.66	6.31	2.40	3.18	2.35
G	14.44	15.53	14.09	8.89	9.16	8.57	14.69	8.87	.61	.24
H	8.67	6.83	5.99	3.64	2.47	1.65	7.16	2.58	1.12	.82
I	11.12	13.96	12.68	7.30	9.39	8.69	12.59	8.46	1.16	.87
J	5.65	11.20	14.97	3.10	5.87	8.14	10.61	5.70	3.83	2.06
K	7.81	13.72	13.00	5.44	8.18	7.66	11.51	7.09	2.63	1.19
L	9.04	13.67	11.38	6.94	9.33	7.81	11.37	8.02	1.89	.99
M	10.75	15.77	16.41	6.63	10.20	10.64	14.31	9.16	2.53	1.79
N	10.38	17.12	11.98	7.40	12.34	7.40	13.16	9.05	2.87	2.33
O	9.34	10.16	6.14	3.11	5.31	2.07	8.54	3.50	1.73	1.35
P	16.09	16.35	17.14	9.83	11.26	12.21	16.53	11.10	.45	.98
Q	14.10	11.38	16.57	9.16	7.81	10.76	14.02	9.24	2.12	1.21
R	13.00	9.63	10.96	3.55	3.98	5.09	11.19	4.21	1.38	.65
S	13.37	13.98	11.33	8.39	4.39	4.80	12.89	5.86	1.13	1.80
T	15.05	14.52	13.38	7.69	6.10	6.23	14.32	6.67	.69	.72
U	9.03	13.08	13.87	2.56	6.10	6.87	11.99	5.18	2.12	1.87
						Total	12.04	6.84	3.53	2.99

C-BAND

Sample	e' 1	e' 2	e' 3	e" 1	e" 2	e" 3	Average e'	Average e"	Std Dev e'	Std Dev e"
F	11.82	12.24	12.67	3.26	3.43	3.61	12.25	3.43	.35	.14
G	10.16	12.05	12.33	2.11	3.09	3.27	11.51	2.82	.96	.51
H	13.25	12.54	15.67	4.54	4.30	5.56	13.82	4.80	1.34	.54
I	7.55	11.62	14.08	3.63	4.70	4.64	11.08	4.32	2.69	.49
J	7.43	9.50	9.01	3.28	3.98	4.09	8.65	3.78	.88	.36
K	16.13	18.44	19.04	7.10	8.00	9.64	17.87	8.25	1.26	1.05
L	13.08	17.65	15.96	6.43	7.34	7.12	15.56	6.96	1.88	.39
M	10.74	14.04	20.47	5.00	6.94	9.75	15.09	7.23	4.04	1.95
N	15.58	16.92	17.07	7.41	7.97	8.01	16.52	7.80	.67	.27
O	22.71	24.16	26.55	9.18	10.16	11.06	24.47	10.14	1.58	.77
P	21.50	23.40	22.61	7.83	8.58	9.15	22.51	8.52	.78	.54
Q	20.33	23.27	24.11	7.97	9.03	9.04	22.57	8.68	1.62	.50
R	15.07	17.43	18.35	6.36	7.93	8.36	16.95	7.55	1.38	.86
S	10.51	11.96	12.41	3.52	4.22	4.11	11.63	3.95	.81	.30
T	13.49	14.36	15.74	3.72	4.13	4.45	14.53	4.10	.93	.30
						Total	15.67	4.77	6.16	2.38

TABLE C5
ASPEN CAMBIUM DIELECTRIC MEASUREMENTS

L-BAND

Sample	e' 1	e' 2	e' 3	e" 1	e" 2	e" 3	Average e'	Average e"	Std Dev e'	Std Dev e"
A-1	7.99	10.79	10.79	2.47	2.85	3.58	9.85	2.97	1.32	.46
A-2	16.43	17.85	12.43	4.99	5.40	3.09	15.57	4.49	2.29	1.01
A-3	3.33	3.79	4.72	.69	1.04	1.04	3.95	.92	.58	.16
A-4	10.09	12.20	10.09	2.82	3.20	2.34	10.79	2.79	.99	.35
B	4.49*	16.41	19.74	.34*	5.88	6.32	18.08	6.10	1.66	.22
C	20.68	22.12	21.39	7.51	7.13	7.09	21.39	7.24	.59	.19
D	10.79	10.79	10.79	3.51	3.15	3.15	10.79	3.27	.00	.17
E	8.69	8.69	7.99	2.77	1.83	1.71	8.45	2.10	.33	.47
F	9.38	17.37	10.09	3.56	5.70	3.09	12.28	4.11	3.61	1.14
G	5.66*	17.61	16.90	.66*	5.33	5.32	17.25	5.33	.36	.01
H	7.75	9.16	10.56	2.02	1.91	3.07	9.16	2.33	1.14	.52
I	5.19*	13.60	16.42	2.00*	4.13	5.61	15.01	4.87	1.41	.74
J	19.26	17.14	18.55	6.03	5.26	6.02	18.32	5.77	.88	.36
K	12.89	22.35	20.21	4.84	7.24	6.68	18.48	6.25	4.05	1.02
L	10.08	19.99	19.27	4.08	5.64	5.62	16.45	5.11	4.51	.73
M	7.98*	18.32	19.27	2.66*	5.57	5.96	18.79	5.77	.47	.19
N	12.19	13.60	13.60	3.69	4.05	4.05	13.13	3.93	.66	.17
O	15.00	19.96	19.26	5.36	6.87	6.49	18.07	6.24	2.19	.64
P	9.39	17.83	17.85	1.60	6.11	5.40	15.02	4.37	3.98	1.98
Q	9.39	4.49*	14.54	2.57	.94*	4.97	11.96	3.77	2.57	1.20
R	12.89	19.26	21.41	5.30	6.45	6.50	17.85	6.08	3.62	.56
S	15.72	14.30	15.01	4.98	4.97	4.98	15.01	4.98	.58	.01
T	13.61	11.49	15.73	3.57	4.23	4.27	13.61	4.02	1.73	.32
						Total	14.88	4.68	4.26	1.60

TABLE C6
DIELECTRIC PROFILES OF ASPEN TREES

Sample	e' 1	e' 2	e' 3	e" 1	e" 2	e" 3	Average e'	Average e"	Std Dev e'	Std Dev e"
Tree 1 - X-band										
Bark	11.07	11.81	11.34	3.29	4.76	4.77	11.41	4.27	.31	.69
Cam 1	19.08	22.87	25.23	15.76	17.74	19.02	22.39	17.51	2.53	1.34
Cam 2	5.67	11.91	11.78	1.59	5.58	6.65	9.79	4.61	2.91	2.18
Cam 3	30.49	29.77	29.90	23.16	21.78	21.13	30.05	22.02	.31	.85
10 mm	15.16	11.99	14.14	8.94	7.12	8.22	13.76	8.09	1.32	.75
35 mm	20.50	18.70	15.97	12.26	11.11	9.29	18.39	10.89	1.86	1.23
55 mm	7.77	7.66	7.54	3.68	3.57	3.46	7.66	3.57	.09	.09
80 mm	11.59	11.64	11.74	6.43	6.45	6.48	11.66	6.45	.06	.02
Tree 1 - C-band										
Bark	9.99	12.35	12.34	.60	1.41	1.68	11.56	1.23	1.11	.46
Cam 1	24.32	26.46	26.04	8.68	9.35	7.20	25.61	8.41	.93	.90
Cam 2	16.71	9.93	14.71	6.13	2.64	5.15	13.78	4.64	2.85	1.47
Cam 3	15.50	26.88	29.58	5.67	8.38	9.21	23.99	7.75	6.10	1.51
10 mm	12.91	14.74	14.74	3.43	3.43	3.43	14.13	3.43	.86	.00
35 mm	7.77	6.56	6.36	.79	.22	.11	6.90	.37	.62	.30
55 mm	11.07	10.67	10.48	4.50	4.21	3.94	10.74	4.22	.25	.23
80 mm	10.29	10.09	10.29	3.57	3.56	3.57	10.23	3.57	.10	.01
Tree 1 - L-band										
Bark	10.09	9.62	9.39	1.96	1.96	1.95	9.70	1.96	.29	.00
Cam 1	26.84	26.12	23.27	10.73	10.35	8.90	25.41	9.99	1.54	.79
Cam 2	18.29	4.96	22.56	6.90	.83	8.64	15.27	5.46	7.50	3.35
Cam 3	24.65	27.08	29.25	10.75	10.86	11.67	26.99	11.10	1.88	.41
10 mm	19.28	14.31	15.02	5.04	4.36	4.37	16.20	4.59	2.20	.32
35 mm	10.79	12.19	12.43	3.14	3.74	3.75	11.80	3.54	.72	.28
55 mm	12.90	12.90	12.90	4.05	4.05	4.05	12.90	4.05	.00	.00
80 mm	10.79	10.79	10.79	3.44	3.44	3.44	10.79	3.44	.00	.00

TABLE C6 (continued)
DIELECTRIC PROFILES OF ASPEN TREES

Sample	e' 1	e' 2	e' 3	e" 1	e" 2	e" 3	Average e'	Average e"	Std Dev e'	Std Dev e"
Tree 2 - X-band										
Bark	4.79	7.59	6.13	.64	2.58	1.53	6.17	1.58	1.14	.79
Cam 1	12.77	12.69	12.16	9.30	9.44	9.14	12.54	9.29	.27	.12
Cam 2	9.22	9.09	8.83	3.61	4.83	5.00	9.05	4.48	.16	.62
Cam 3	7.42	5.12	3.94	4.06	1.90	.95	5.49	2.30	1.44	1.30
20 mm	6.17	5.58	6.12	2.78	2.41	3.37	5.96	2.85	.27	.40
35 mm	5.86	5.47	5.47	2.51	2.24	2.24	5.60	2.33	.19	.12
55 mm	6.43	5.70	5.73	2.74	2.52	2.60	5.95	2.62	.34	.09
Tree 2 - C-band										
Bark	8.51	9.14	9.55	1.63	1.30	1.43	9.07	1.45	.43	.13
Cam 1	14.29	18.38	18.88	5.92	7.51	7.63	17.18	7.02	2.06	.78
Cam 2	6.69	10.94	10.53	.93	3.43	3.15	9.39	2.50	1.91	1.12
Cam 3	13.56	12.67	14.71	5.69	4.40	5.70	13.65	5.26	.83	.61
20 mm	6.47	6.60	6.87	2.03	2.15	2.15	6.65	2.11	.17	.05
35 mm	5.88	6.14	6.14	1.79	1.91	1.91	6.05	1.87	.12	.05
55 mm	4.43	5.01	5.08	2.09	2.31	2.31	4.84	2.24	.29	.11
Tree 2 - L-band										
Bark	3.33	4.26	4.96	.28	.28	.28	4.18	.28	.67	.00
Cam 1	8.68	16.41	15.69	3.72	6.24	6.54	13.60	5.50	3.49	1.26
Cam 2	9.61	11.01	11.02	4.00	5.21	4.31	10.55	4.51	.66	.51
Cam 3	12.89	14.29	10.09	5.26	5.58	3.43	12.42	4.76	1.75	.95
20 mm	8.68	9.39	8.68	3.12	3.12	3.12	8.92	3.12	.33	.00
35 mm	5.42	5.42	5.42	1.40	1.40	1.68	5.42	1.49	.00	.13
55 mm	5.19	5.89	5.19	1.11	1.40	1.11	5.42	1.21	.33	.13

Figure A1.

Views to East from Site

Site AS Reflector #1

Figure A1 concluded.

View of the Site from West

View of the Site from East

Site AS Reflector #1

Figure A2.

Views to East from Site

Site AS Reflector #2

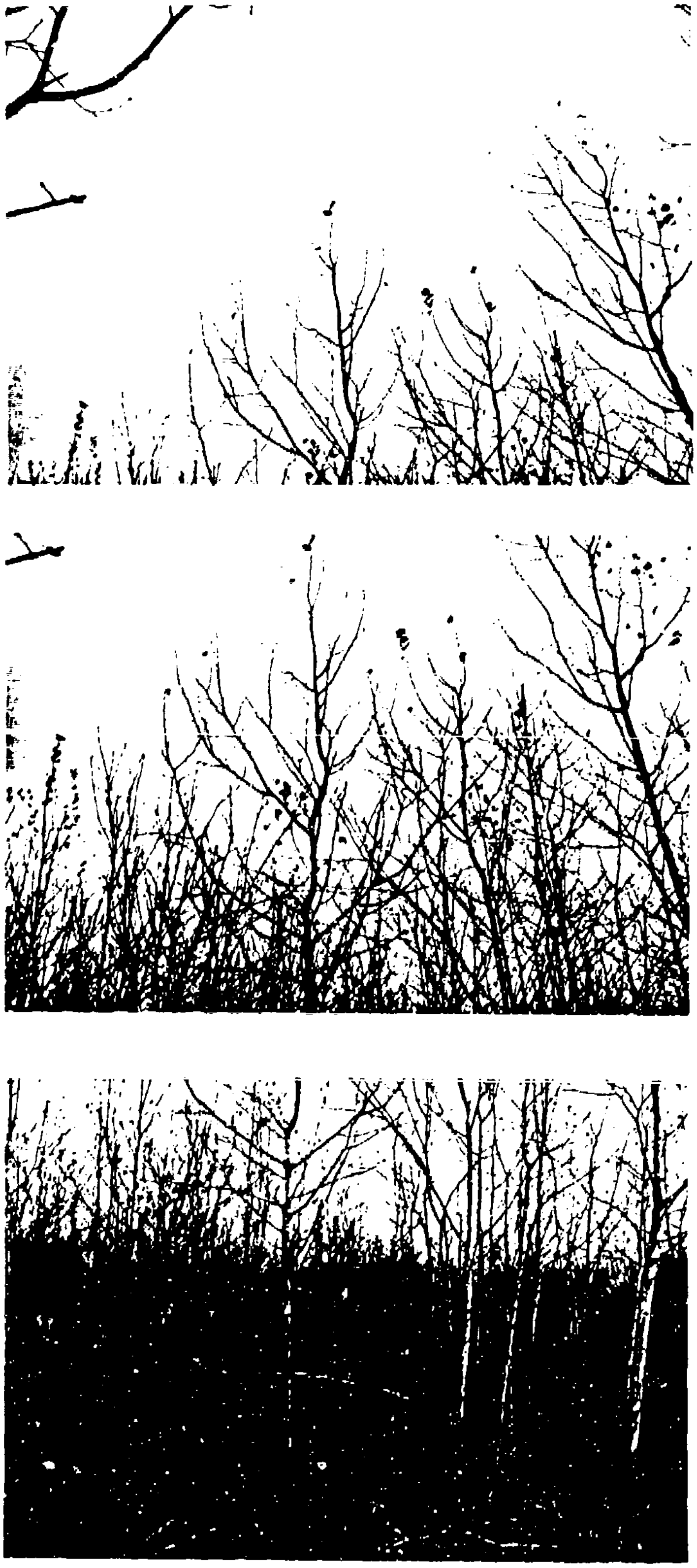
Figure A2 concluded.

View of the Site from West

View of the Site from East

Site AS Reflector #2

Figure A3.



Views to East from Site

Site AS Reflector #3

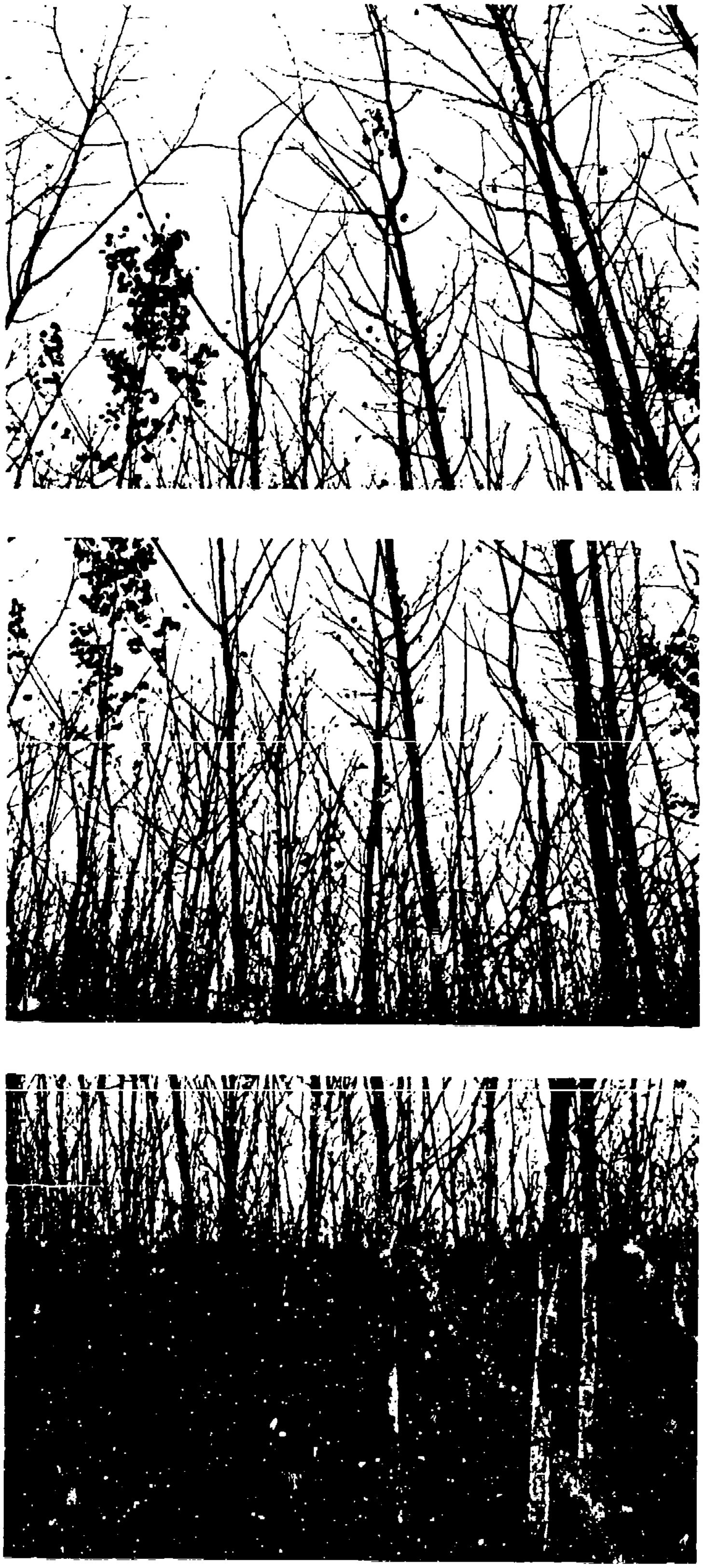
Figure A3 concluded.

View of the Site from West

View of the Site from East

Site AS Reflector #3

Figure A4.



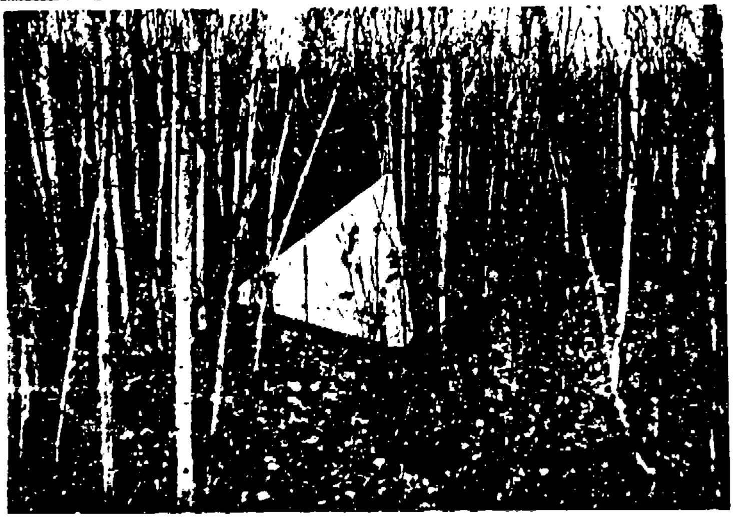
Views to East from Site

Site AS Reflector #4

Figure A4 concluded.

View of the Site from West

View of the Site
from East



View of the Site
from North

Site AS Reflector #4

Figure A5.

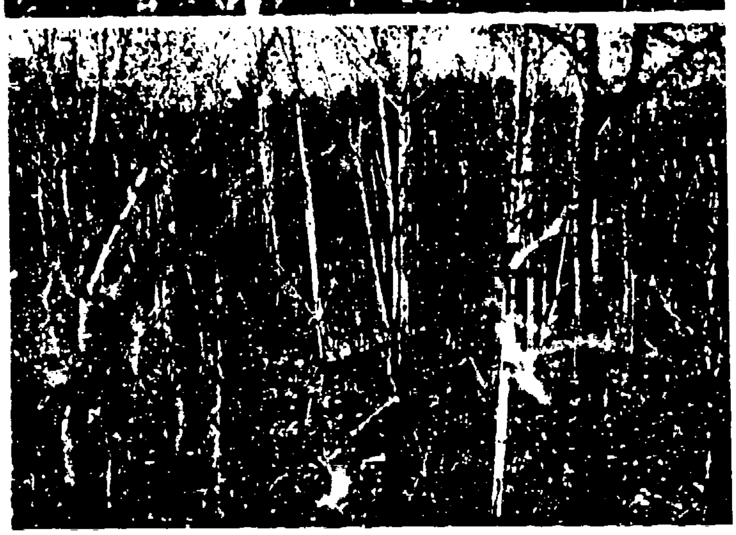
Views to East from Site

Site AS Reflector #5

Figure A5 concluded.

View of the Site from West

View of the Site from East



View of the Site from South

Site AS Reflector #5

Figure A6.

Views to East from Site

Site AS Reflector #6

Figure A6 concluded.

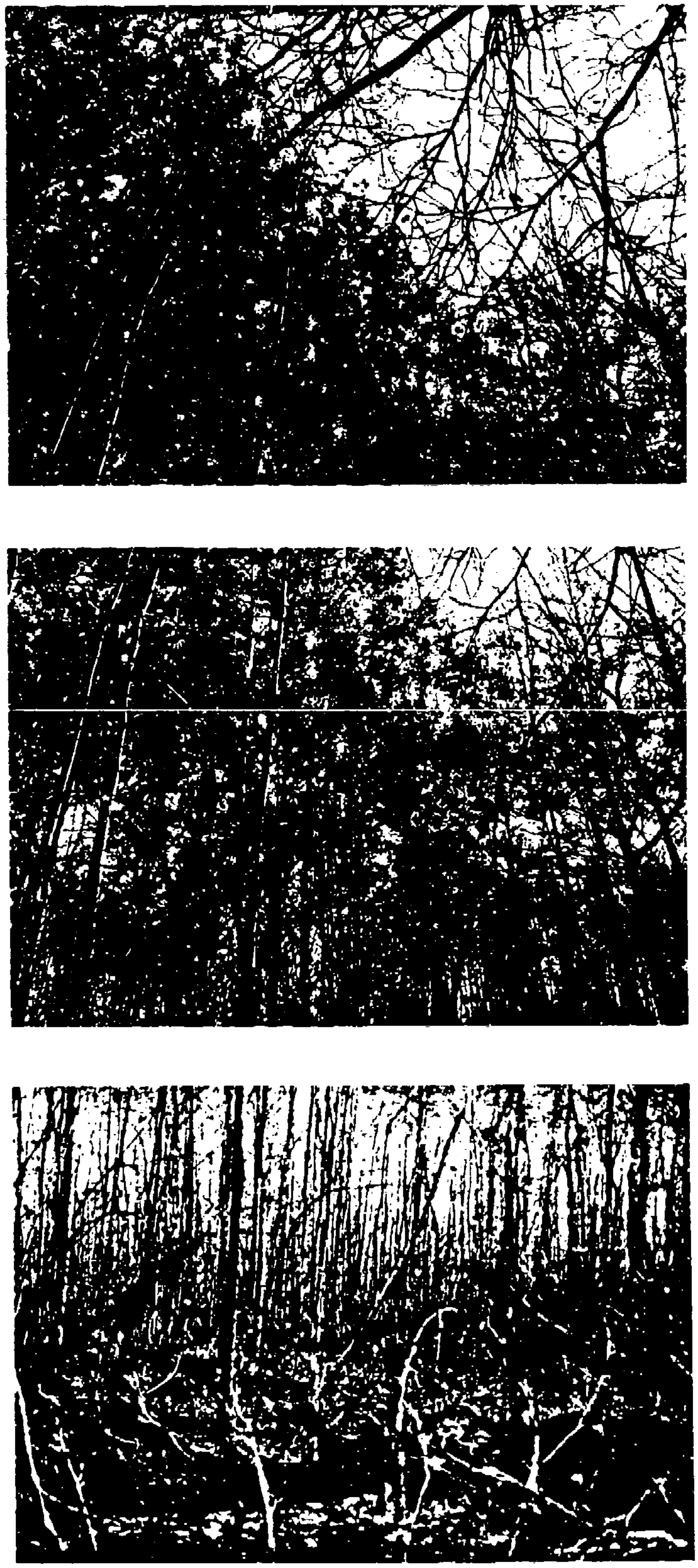
View of the Site from West

View of the Site from East

View of the Site from North

Site AS Reflector #6

Figure A7.

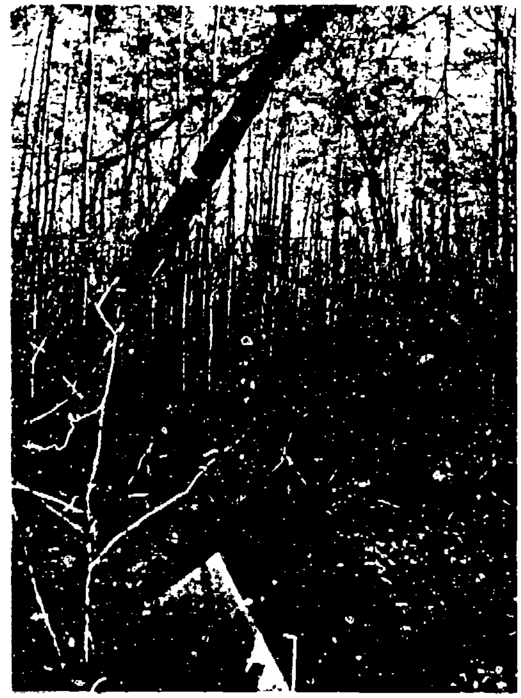


Views to East from Site

Site AM Reflector #1

Figure A7 concluded.

View of the Site from East



View of the Site from West

View of the Site from South

Site AM Reflector #1

Figure A8.

Views to East from Site
Site AM Reflector #2

Views to 304^0 Look Direction from Site

Site AM Reflector #2

Figure A8 concluded.

View of the Site from East

View of the Site from North

Site AM Reflector #2

Figure A9.

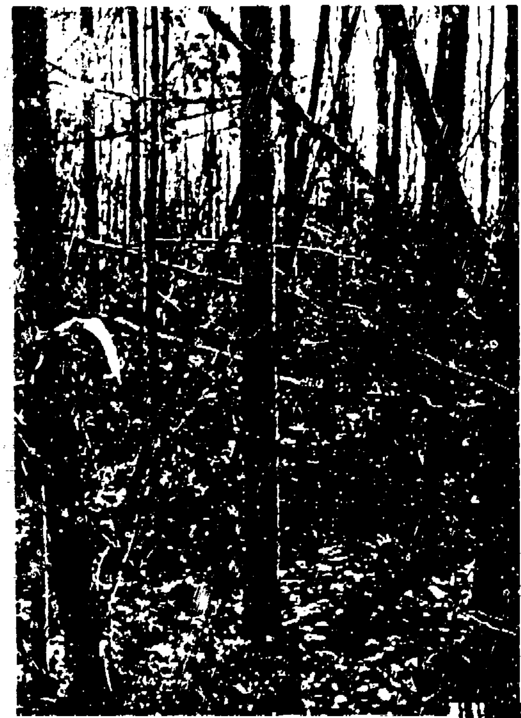
Views to East frcm Site

Site AM Reflector #3

Views to 304° Look Direction from Site

Site AM Reflector #3

Figure A9 concluded.



View of the Site
from North

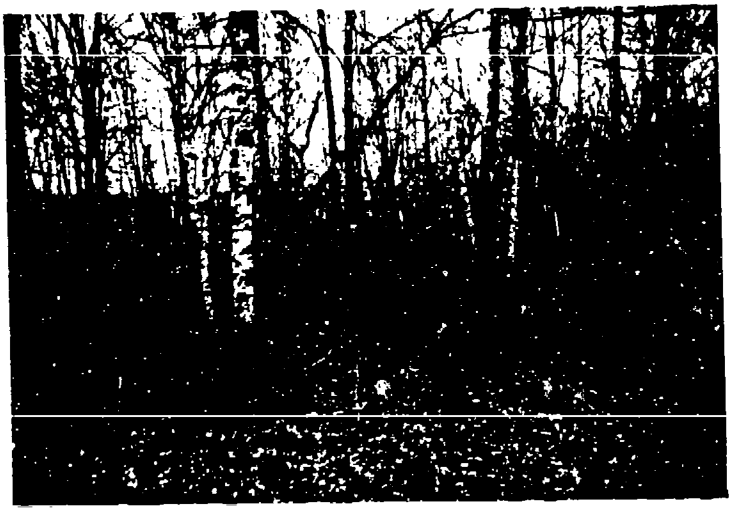
View of the Site
from East

View of the Site
from West

Site AM Reflector #3

Figure A10.

Views to East from Site
Site AM Reflector #4



Views to 304° Look Direction from Site

Site AM Reflector #4

View of the Site
from South

View of the Site
from East

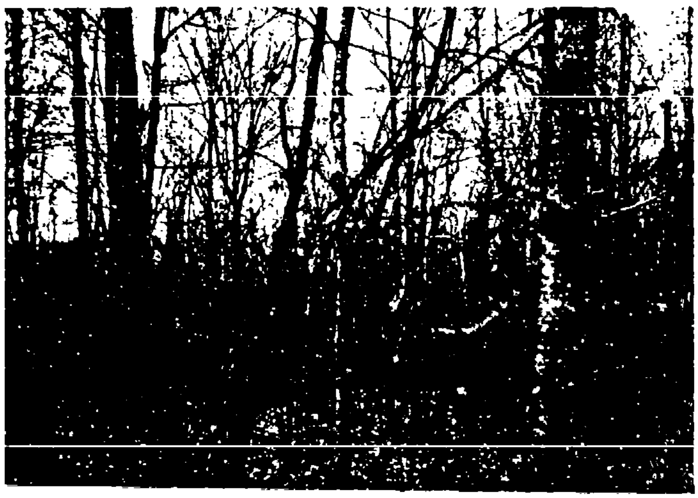
Site AM Reflector #4

Figure A11.

Views to East from Site

Site AM Reflector #5

Figure A11 continued.



Views to 304^0 Look Direction from Site

Site AM Reflector #5

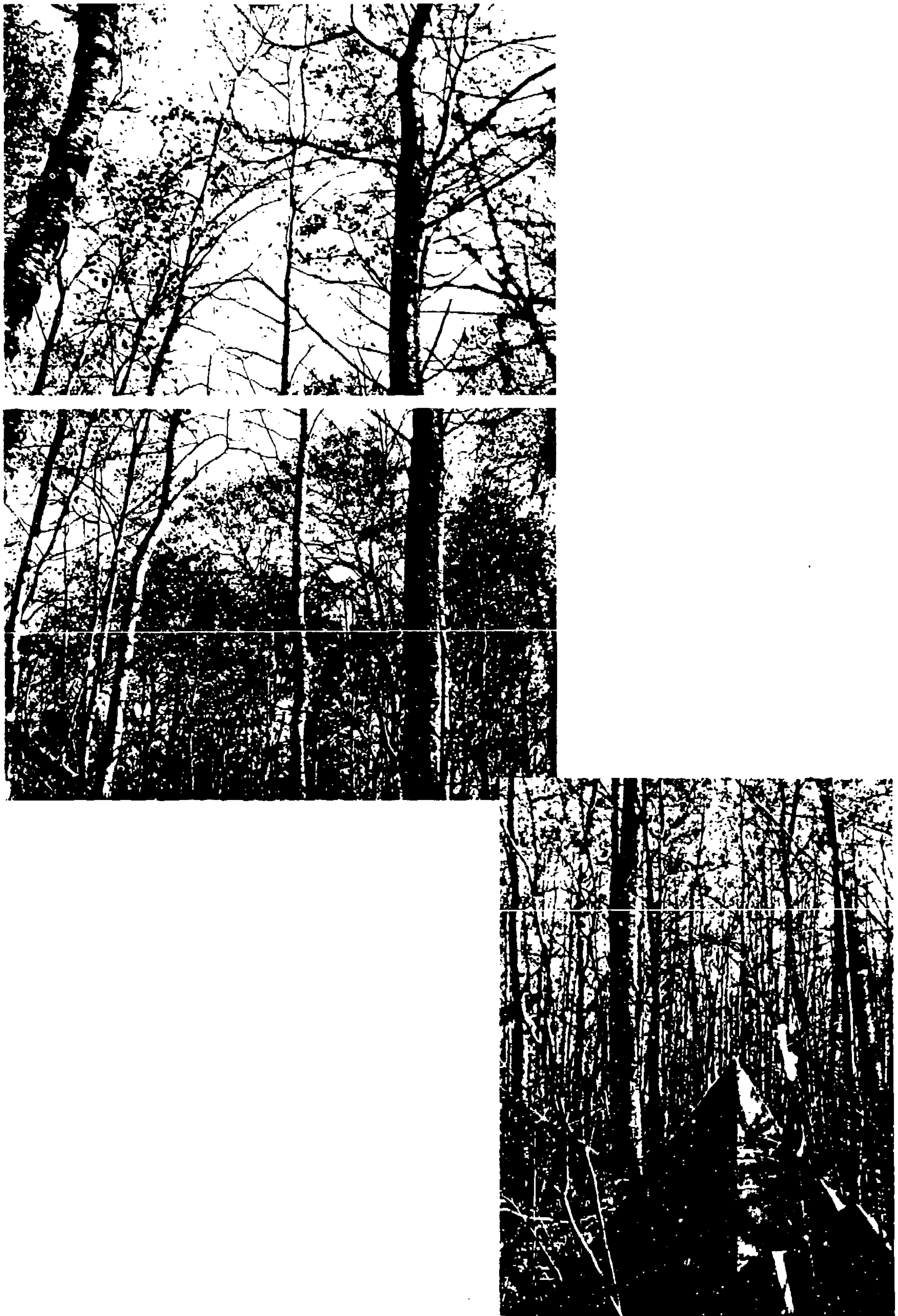
View of the Site
from North

View of the Site
from East

View of the Site
from South

Site AM Reflector #5

Figure A12.



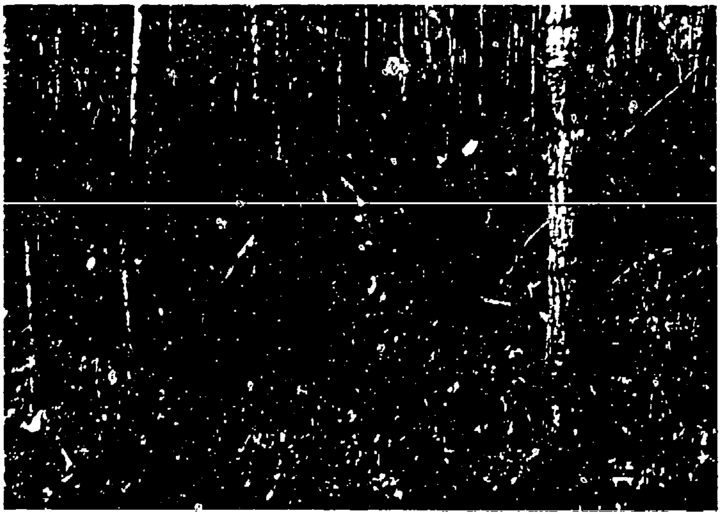
Views to East from Site
Site AD Reflector #1

Views to 304^0 Look Direction from Site

Site AD Reflector #1

Figure A12 concluded.

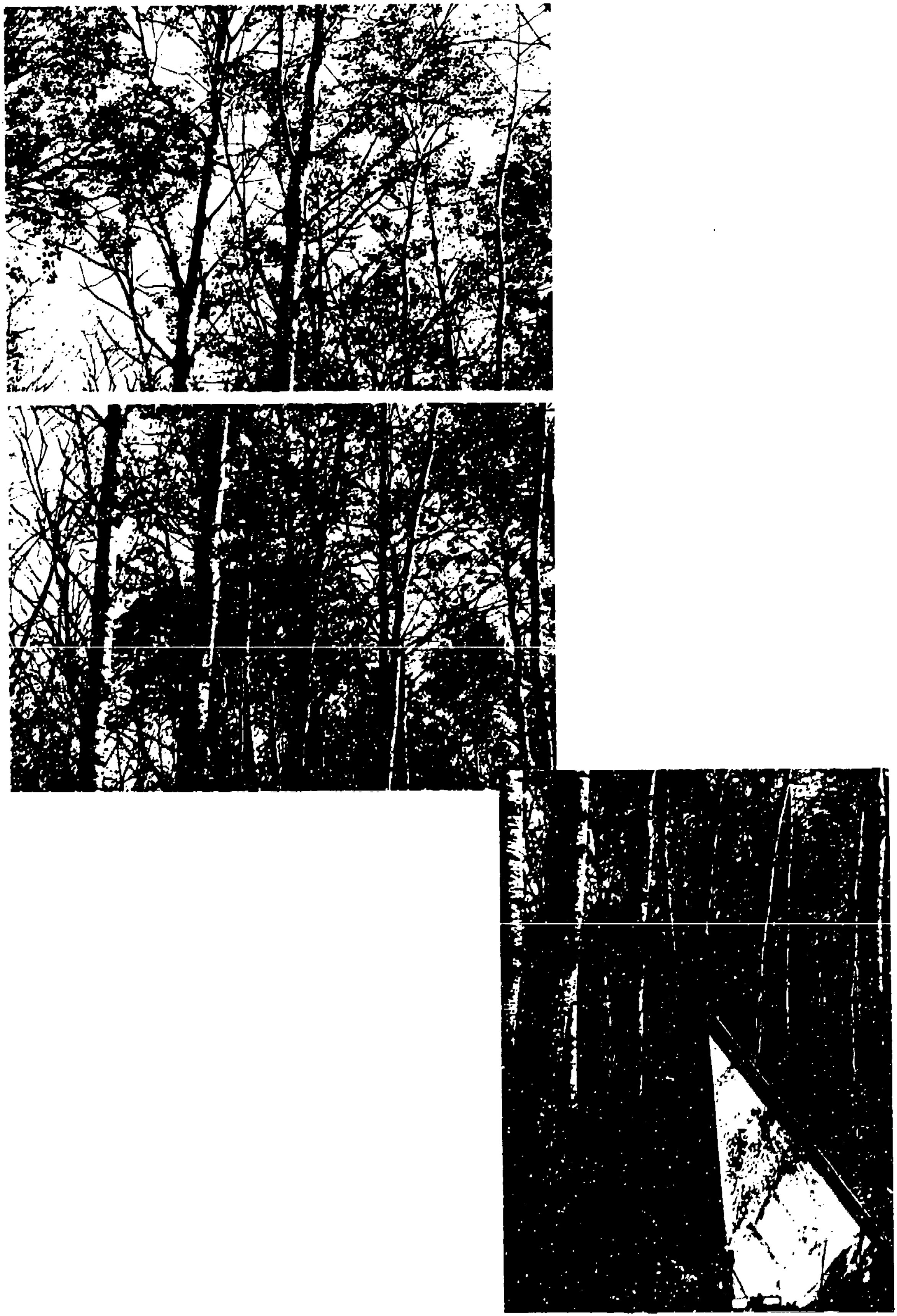
View of the Site from North



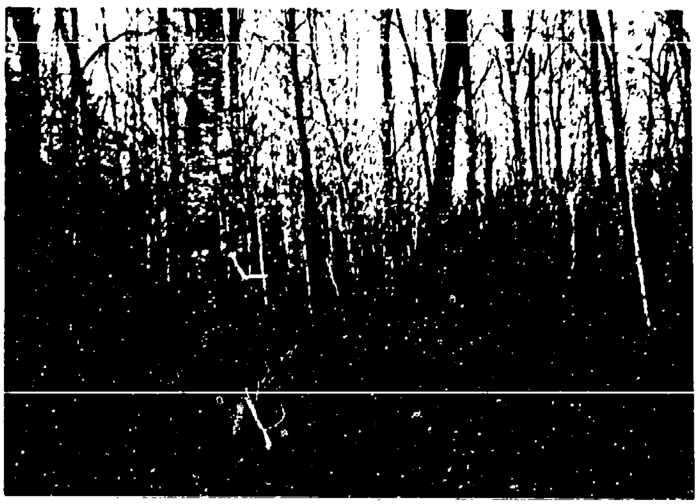
View of the Site from East

Site AD Reflector #1

Figure A13.



Views to East from Site
Site AD Reflector #2



Views to 304^{0} Look Direction from Site

Site AD Reflector #2

Figure A13 concluded.

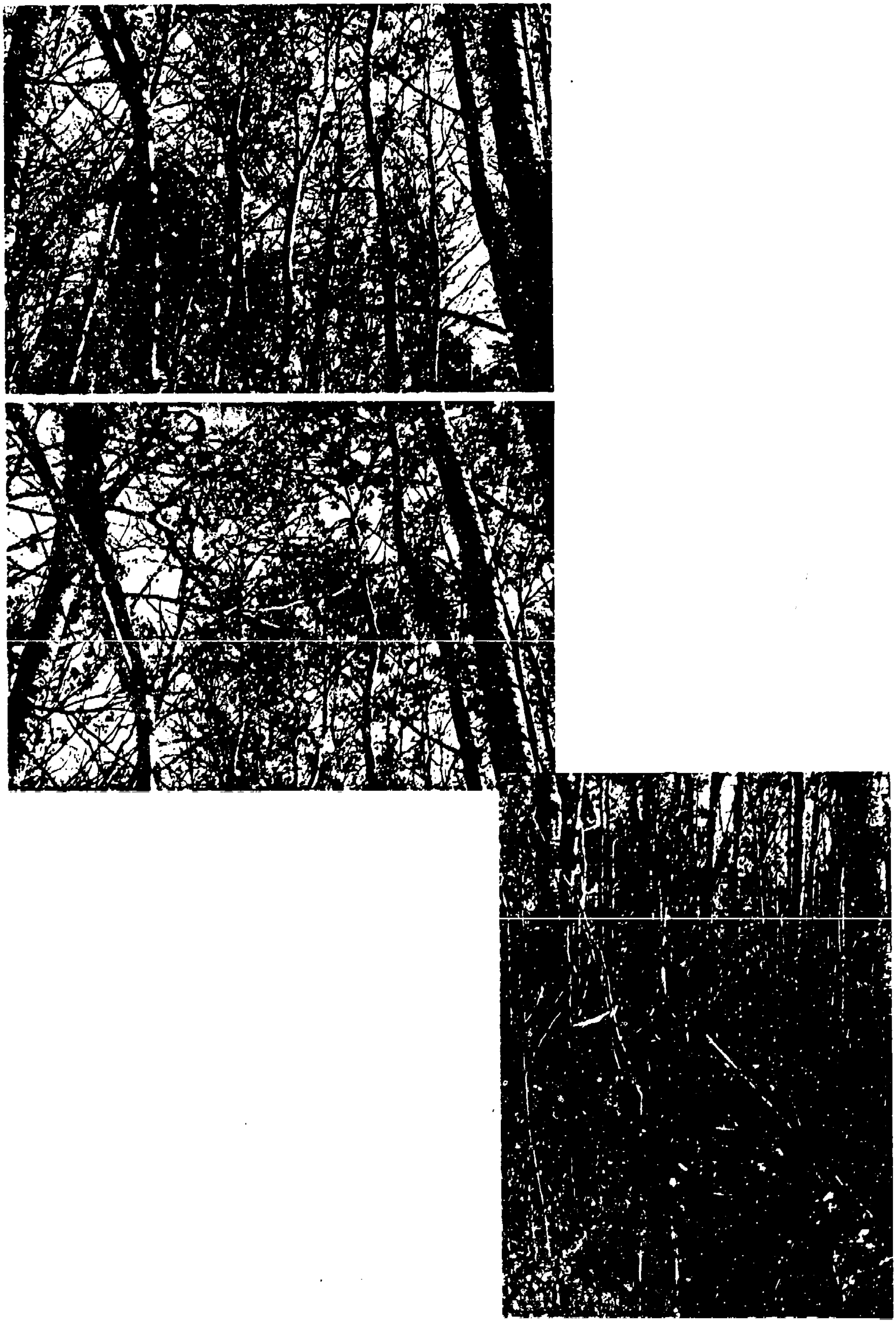
View of the Site
from North

View of the Site
from North

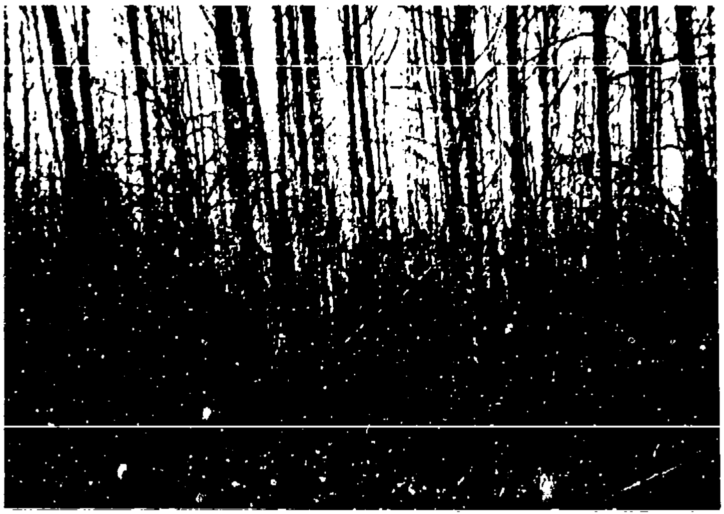
View of the Site
from East

Site AD Reflector #2

Figure A14.



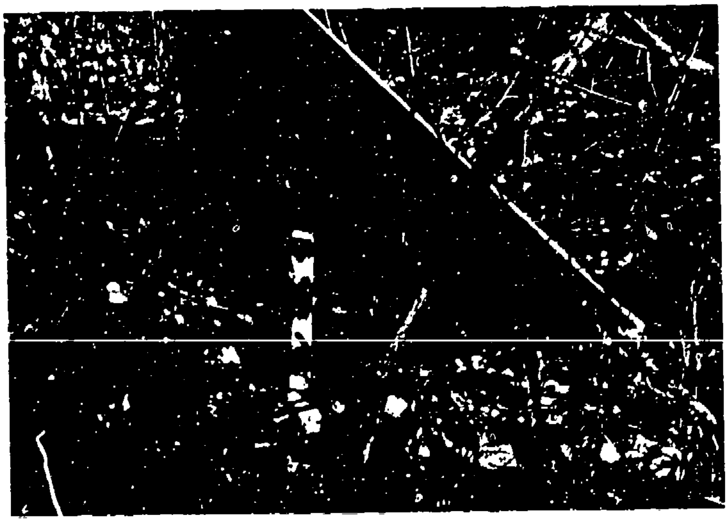
Views to East from Site
Site AD Reflector #3



Views to 304° Look Direction from Site

Site AD Reflector #3

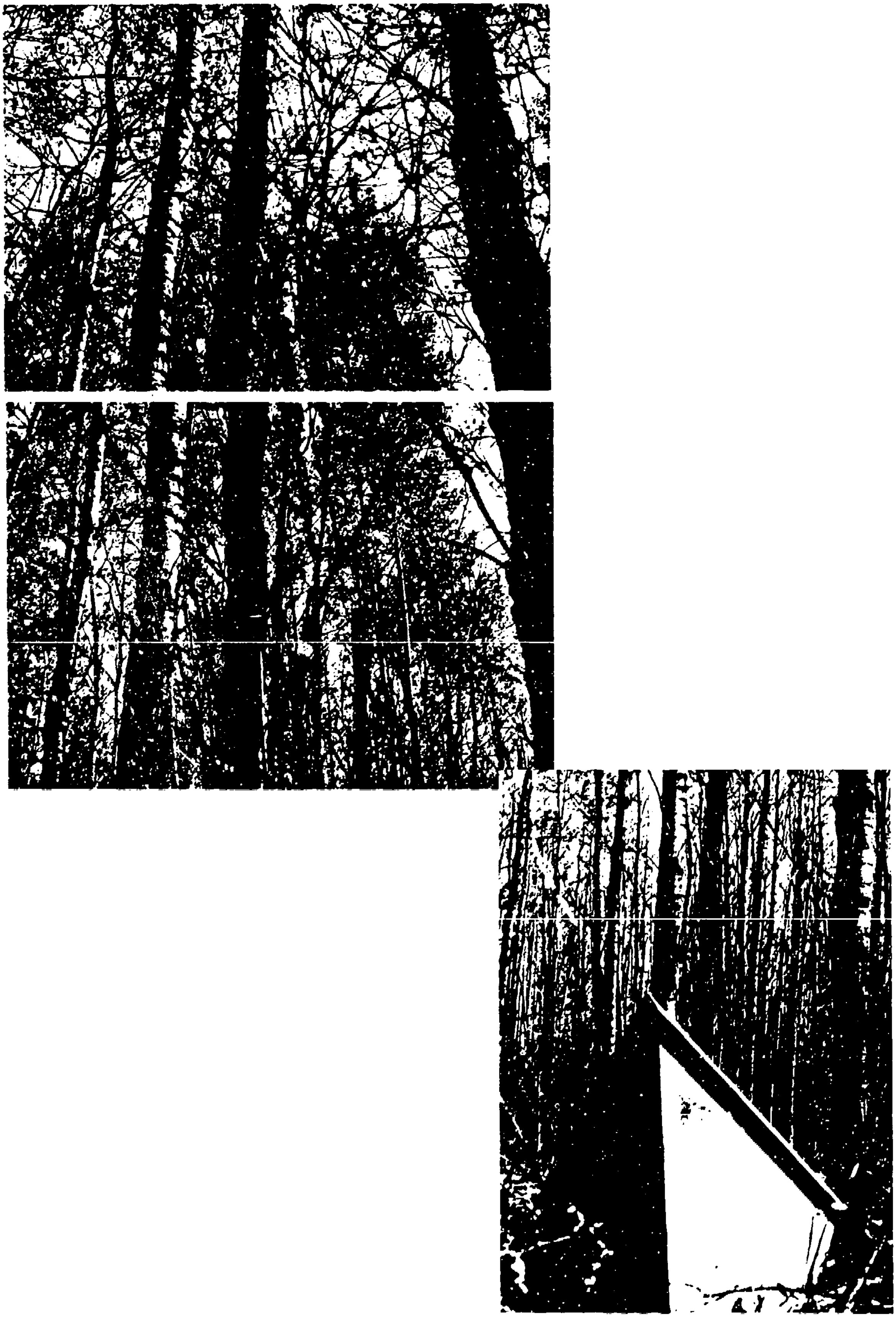
View of the Site from North



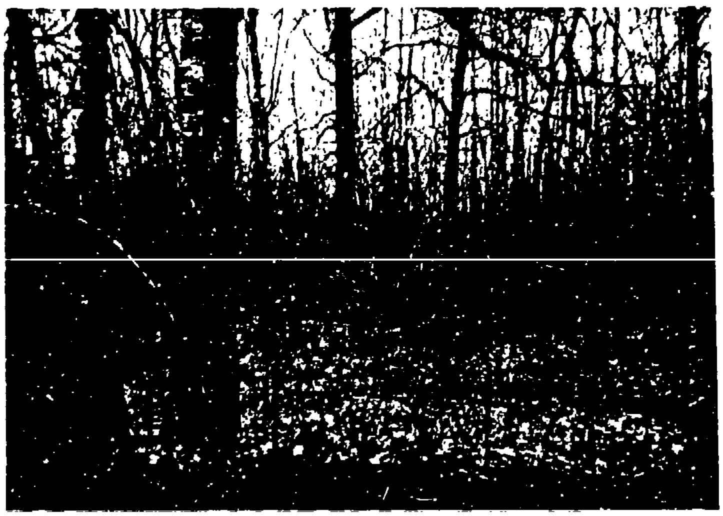
View of the Site from South

Site AD Reflector #3

Figure A15.



Views to East from Site
Site AD Reflector #4



Views to 304° Look Direction from Site

Site AD Reflector #4

View of the Site from North

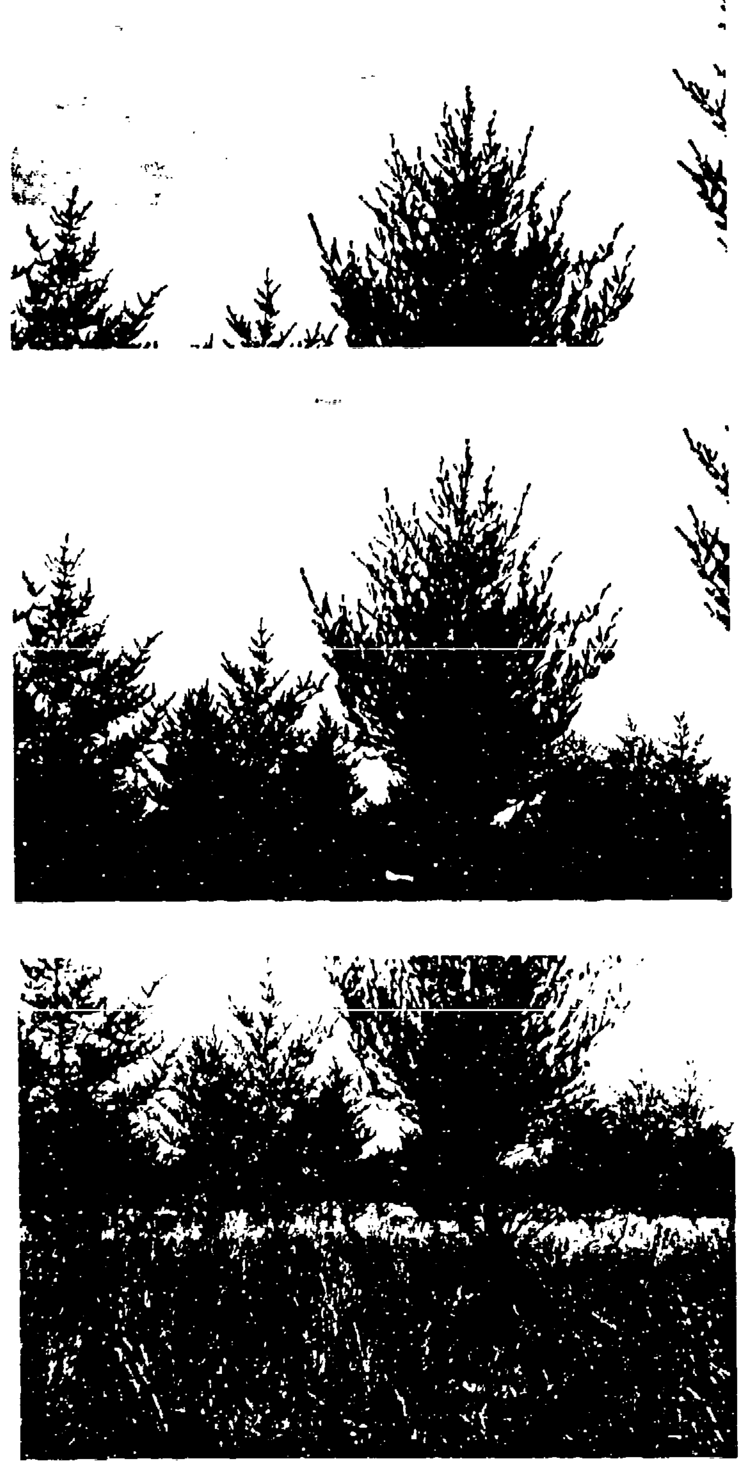
Site AD Reflector #4

Figure A16.

Views to 304^{0} Look Direction from Site

Site AD Reflector #5

Figure A17.

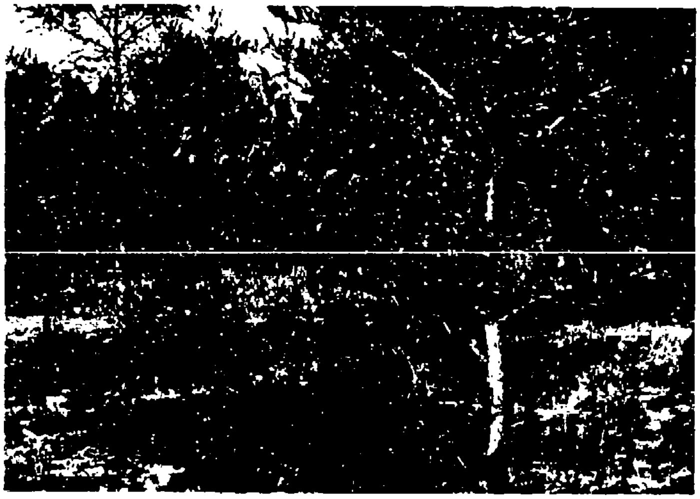


Views to East from Site

Site JS Reflector #1

Figure A17 concluded.

View of the Site from North



View of the Site from East

View of the Site from West

Site JS Reflector #1

Figure A18.

Views to East from Site

Site JS Reflector #2

Figure A18 concluded.

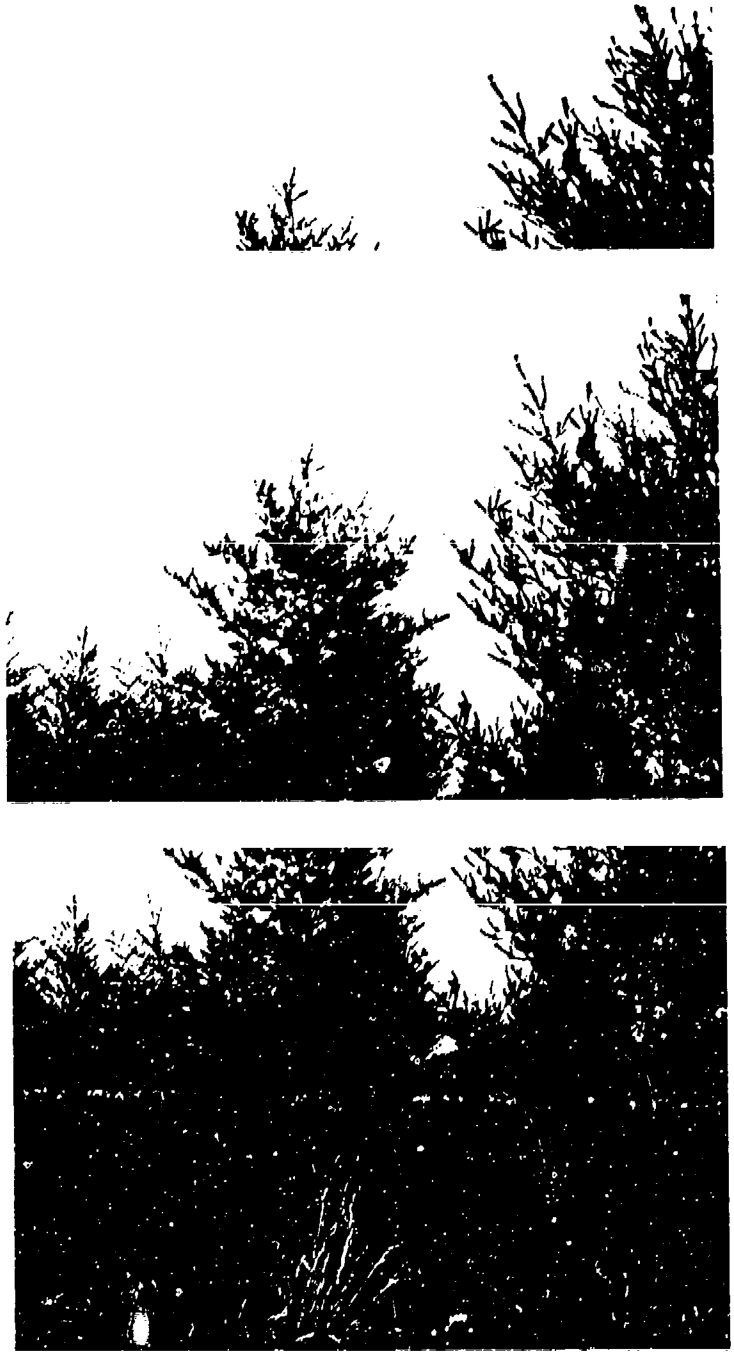
View of the Site from North

View of the Site from West

View of the Site from East

Site JS Reflector #2

Figure A19.



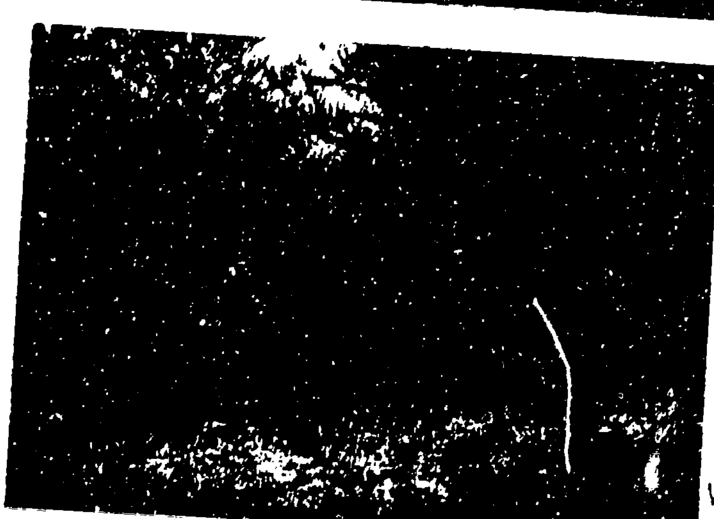
Views to East from Site

Site JS Reflector #3

Figure A19 concluded.

View of the Site
from North

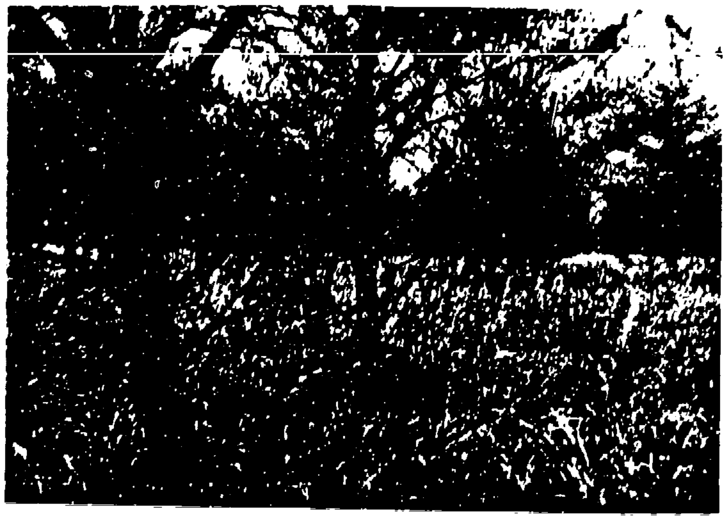
View of the Site
from East



View of the Site
from West

Site JS Reflector #3

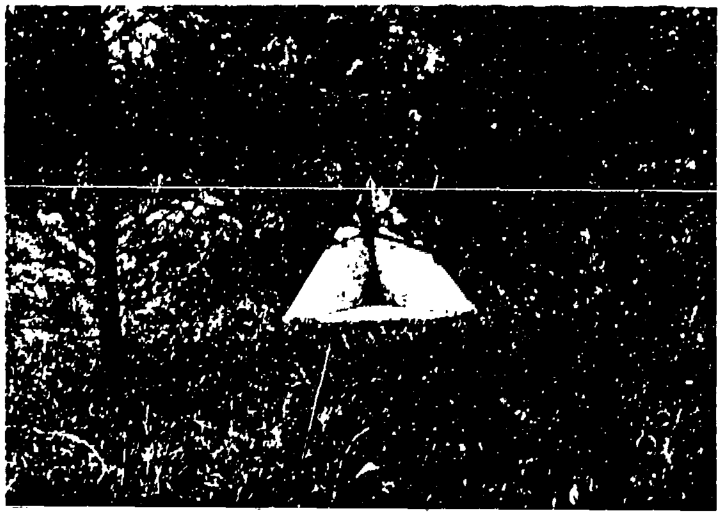
Figure A20.



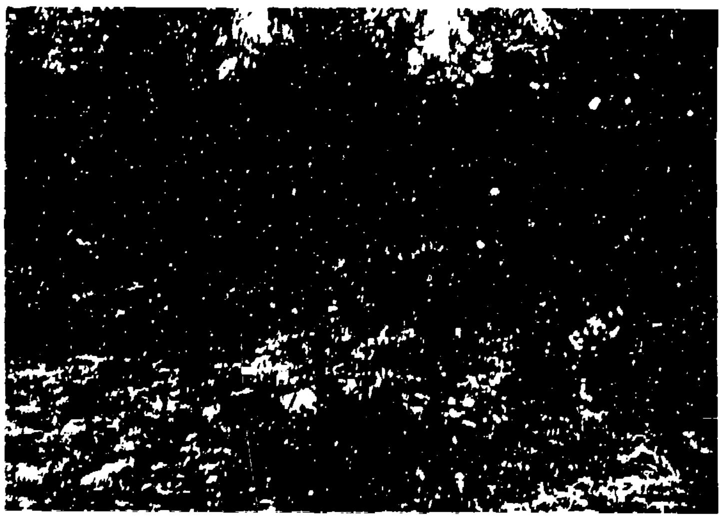
Views to East from Site

Site JS Reflector #4

View of the Site
from North



View of the Site
from East



View of the Site
from West

Site JS Reflector #4

Figure A21.

Views to East from Site

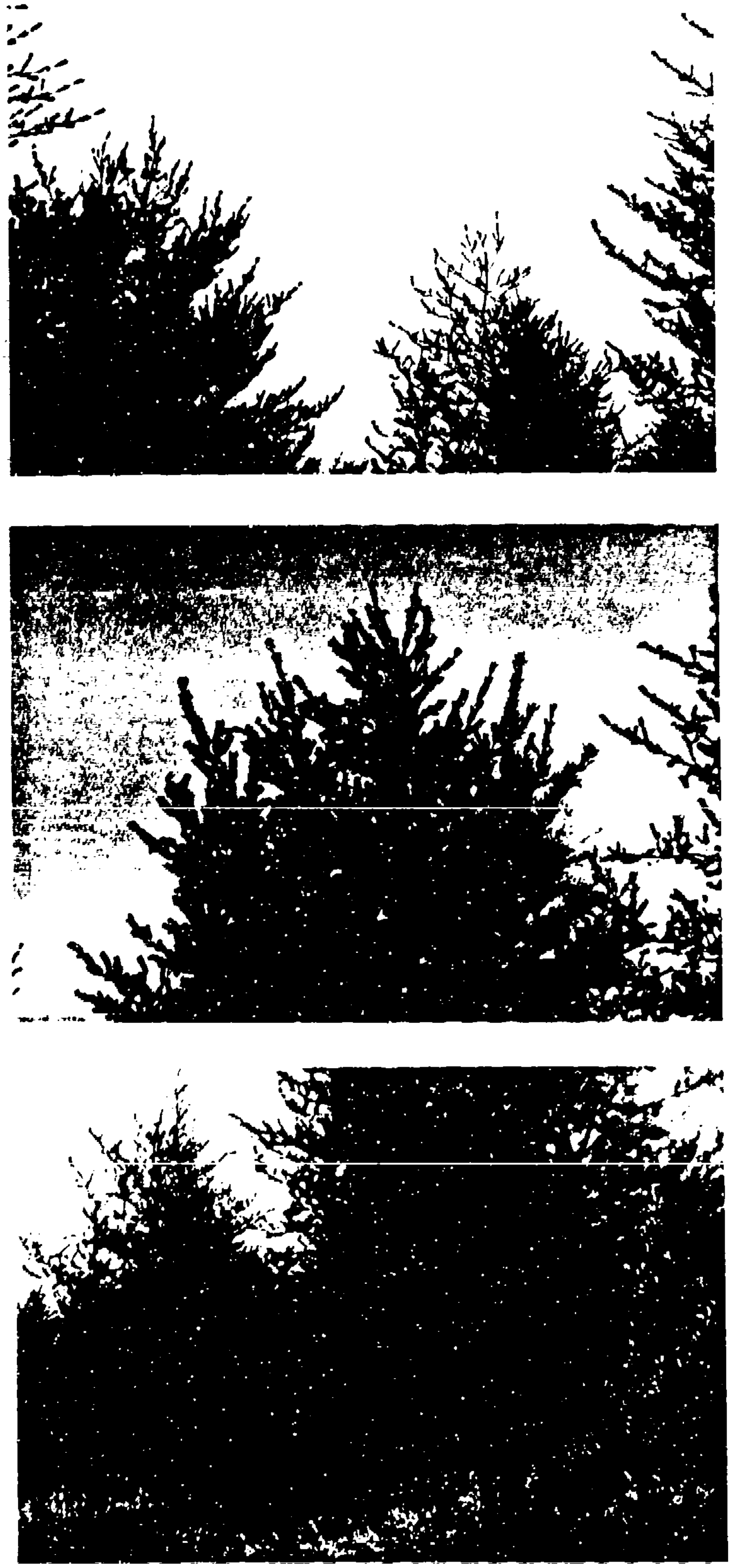
Site JS Reflector #5

View of the Site from North

View of the Site from East

Site JS Reflector #5

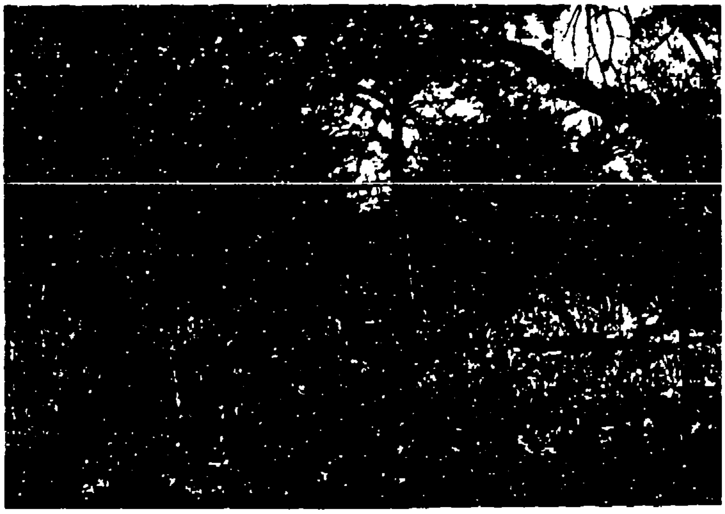
Figure A22.

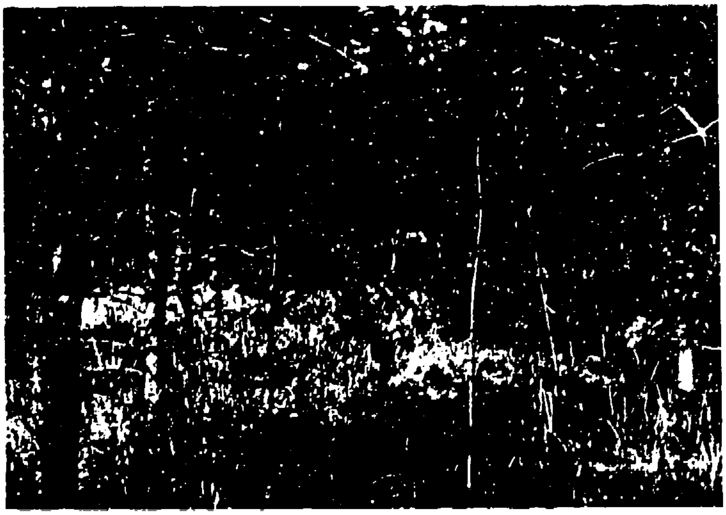


Views to East from Site

Site JS Reflector #6

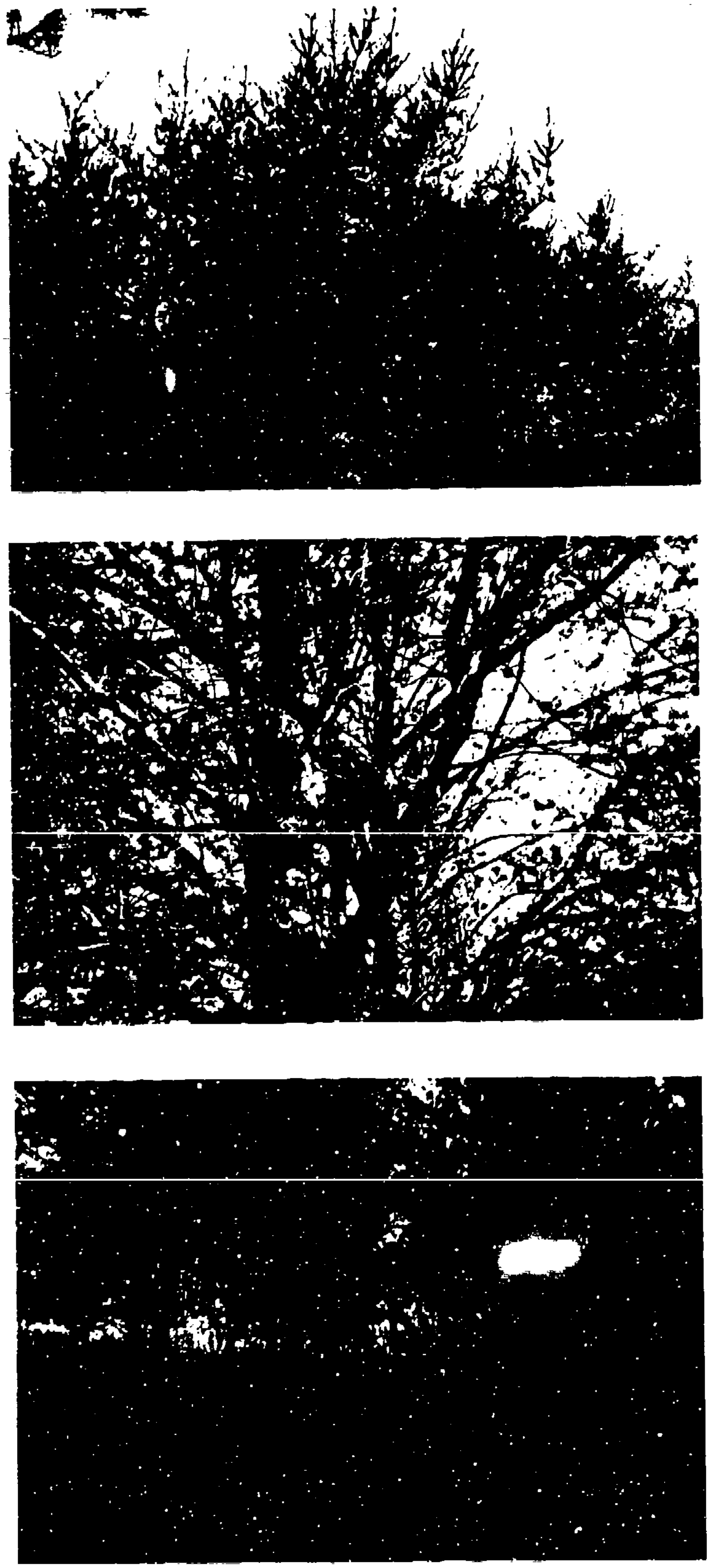

View of the Site from North


View of the Site from West


View of the Site from East

Site JS Reflector #6

Figure A23.



Views to East from Site

Site JM Reflector #1

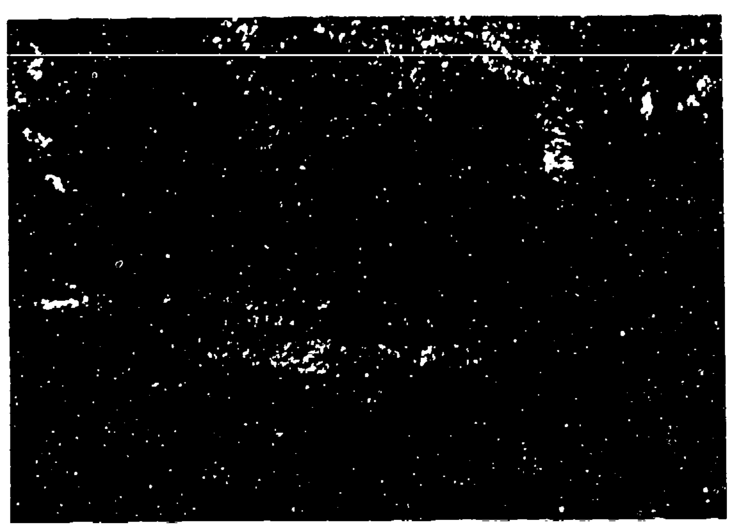
View of the Site
from North

View of the Site
from East

View of the Site
from South

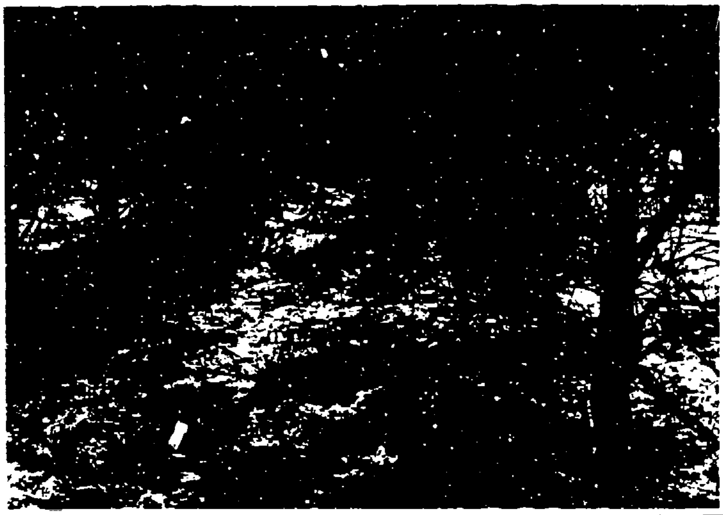
Site JM Reflector #1

Figure A24.



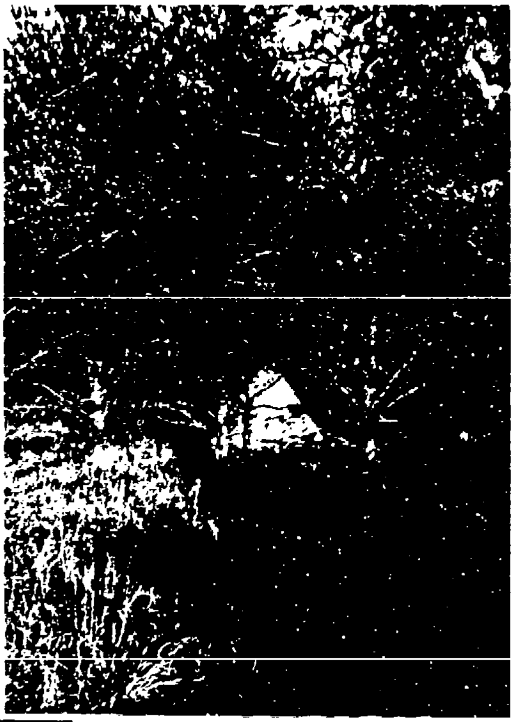
Views to East from Site

Site JM Reflector #2



View of the Site
from North

View of the Site
from East



View of the Site
from West

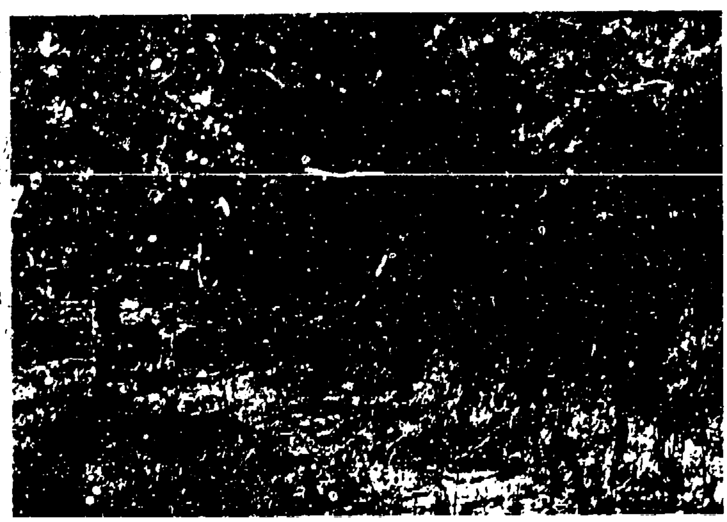
Site JM Reflector #2

Figure A25.

Views to East from Site

Site JM Reflector #3

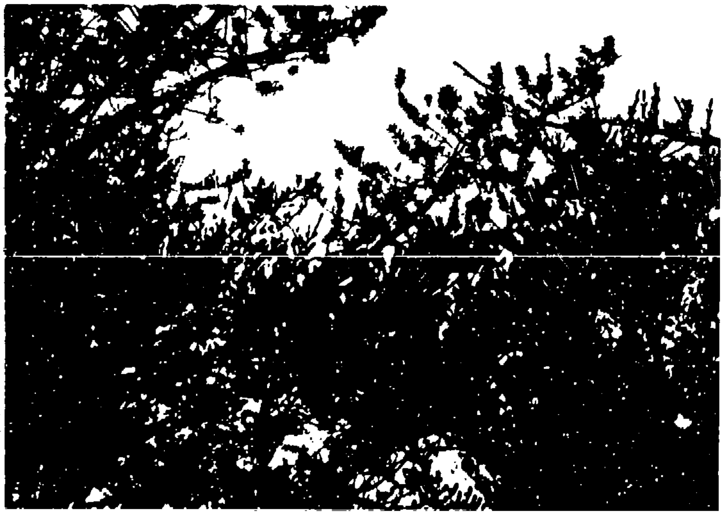

View of the Site from North

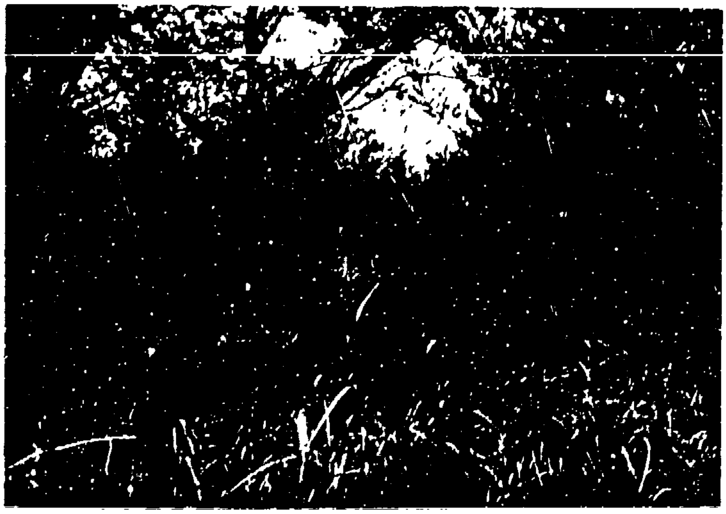

View of the Site from East


View of the Site from West

Site JM Reflector #3

Figure A26.

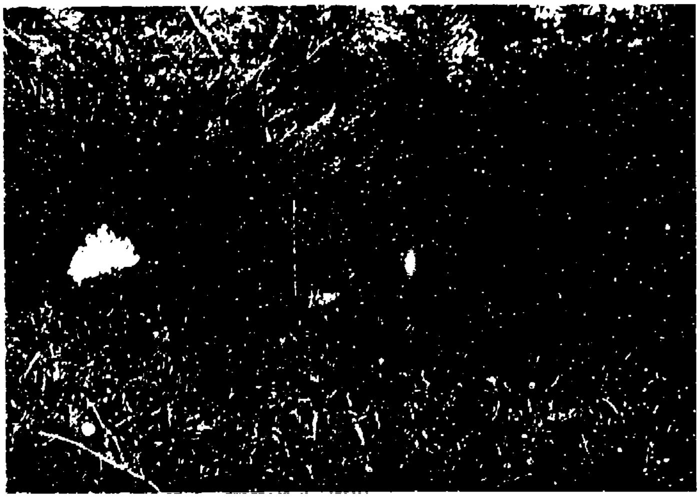




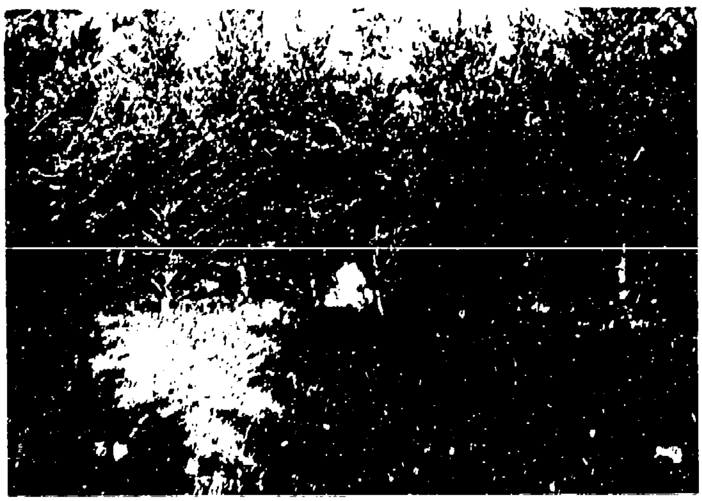
Views to East from Site

Site JM Reflector #4

Figure A26 concluded.



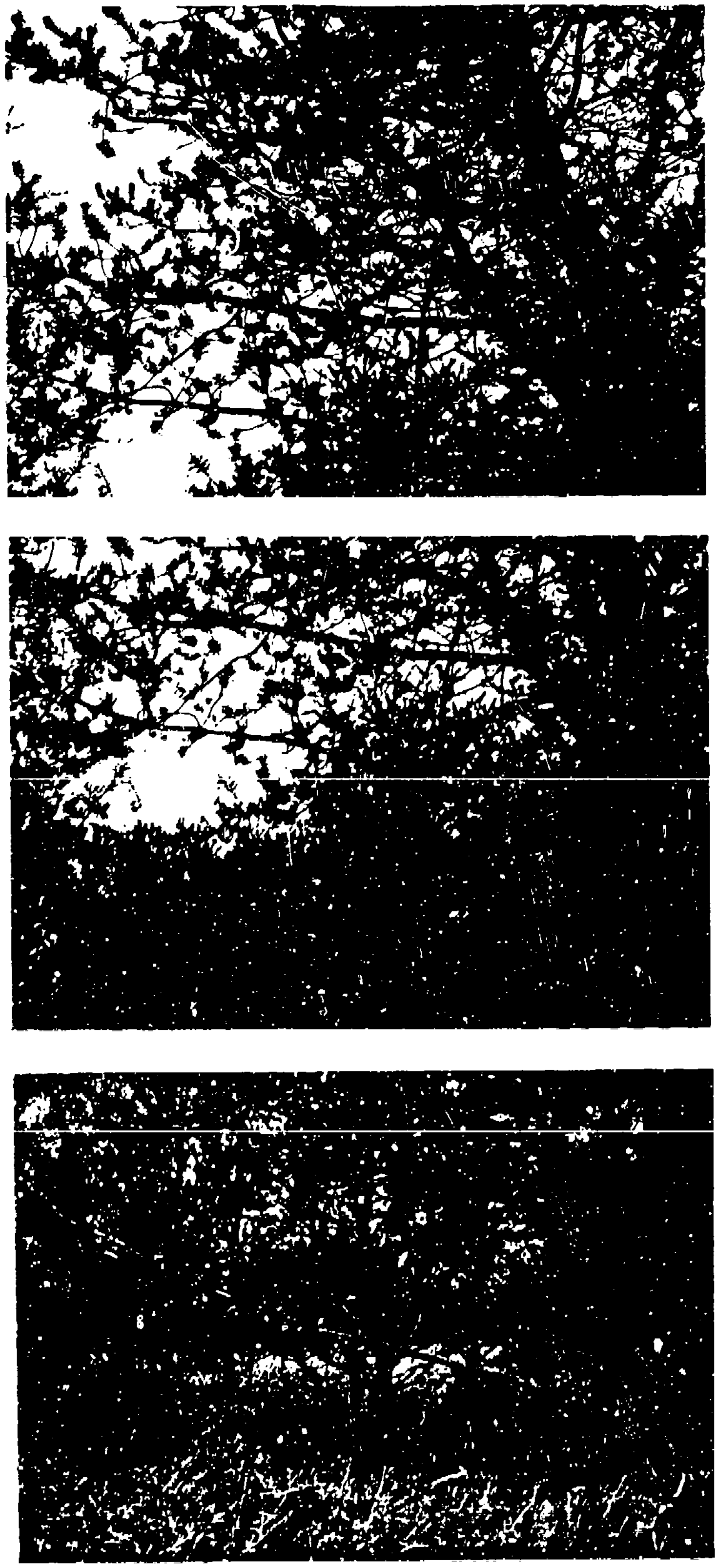
View of the Site from South



View of the Site from West

Site JM Reflector #4

Figure A27.

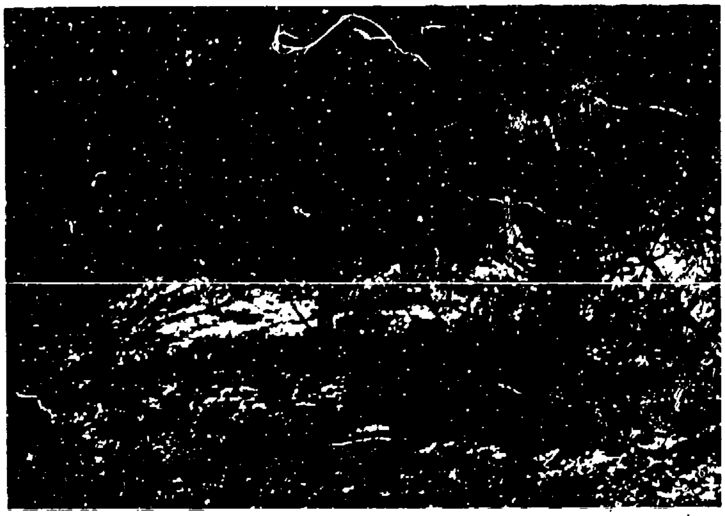


Views to East from Site

Site JM Reflector #5

Figure A27 concluded.

View of the Site from North



View of the Site from East

View of the Site from West

Site JM Reflector #5

Figure A28.

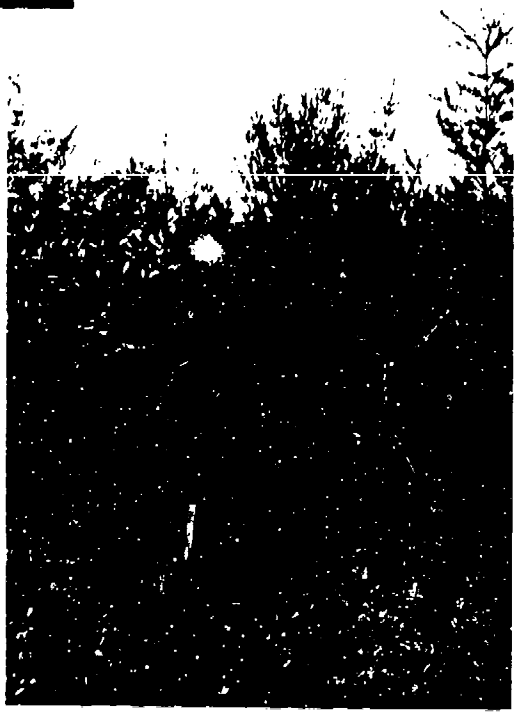
Views to East from Site

Site JM Reflector #6

Figure A28 concluded.

View of the Site
from North

View of the Site
from East



View of the Site
from West

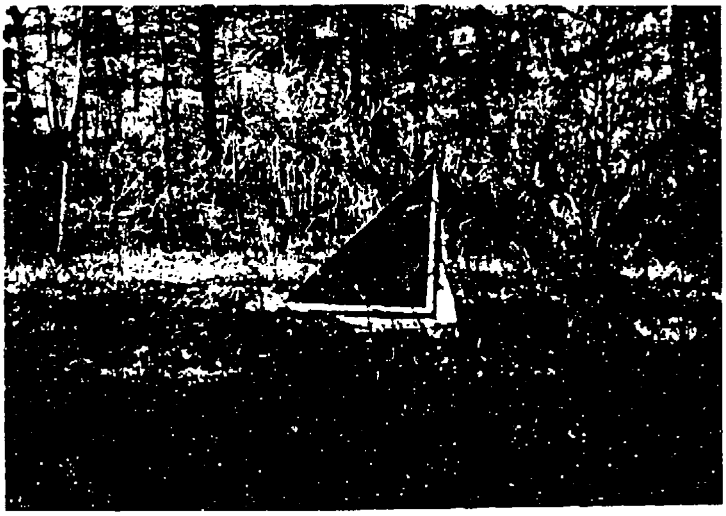
Site JM Reflector #6

Figure A29.

Views to East from Site

Site JD Reflector #1

Figure A29 concluded.



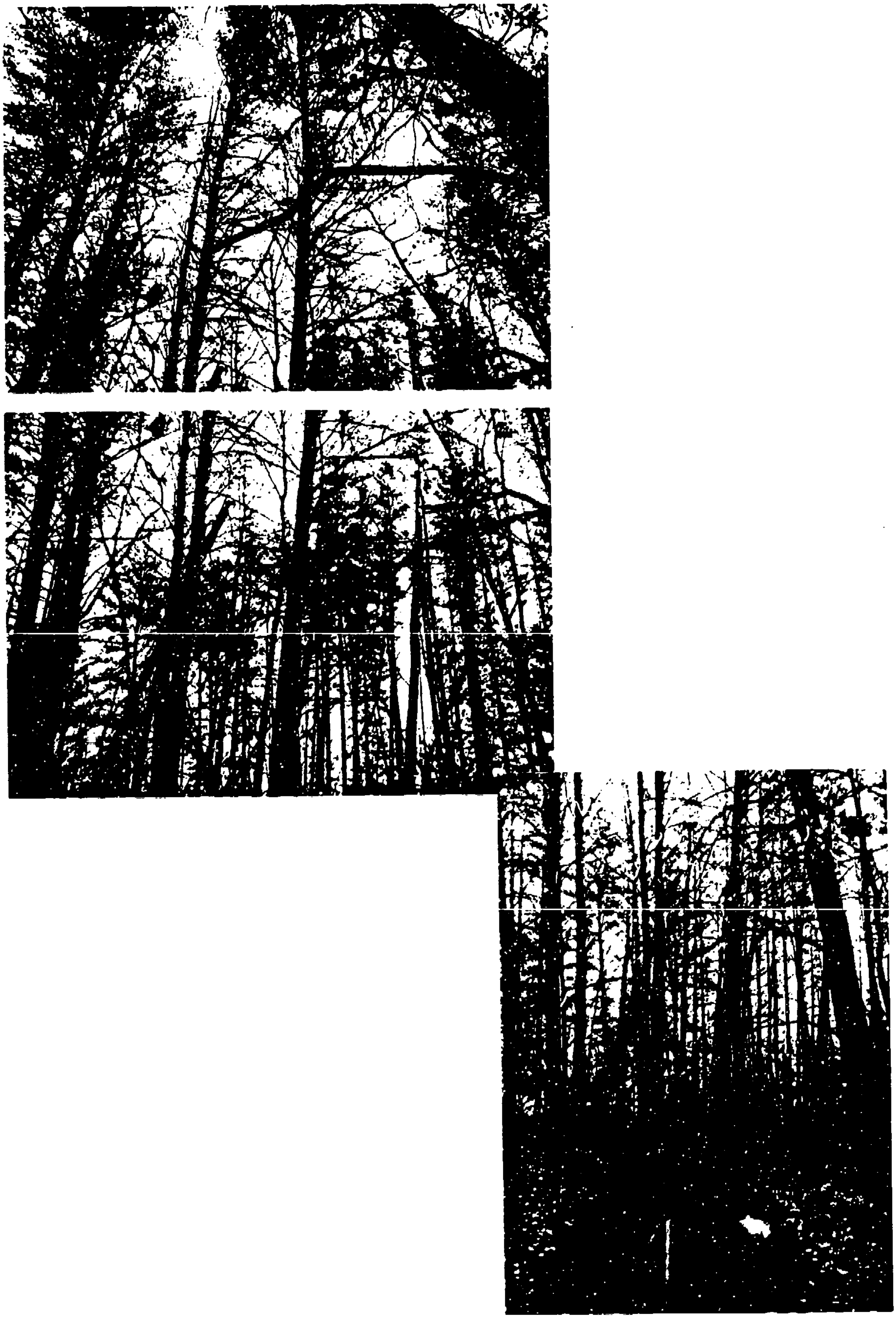
View of the Site from North

View of the Site from East

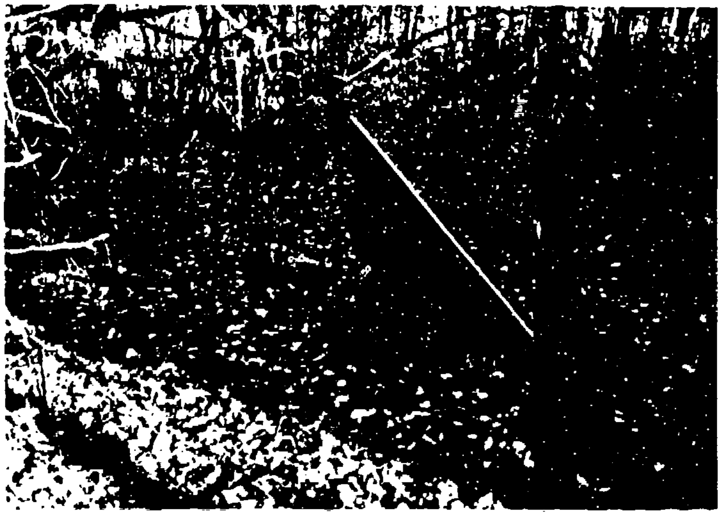
View of the Site from West

Site JD Reflector #1

Figure A30.



Views to East from Site
Site JD Reflector #2



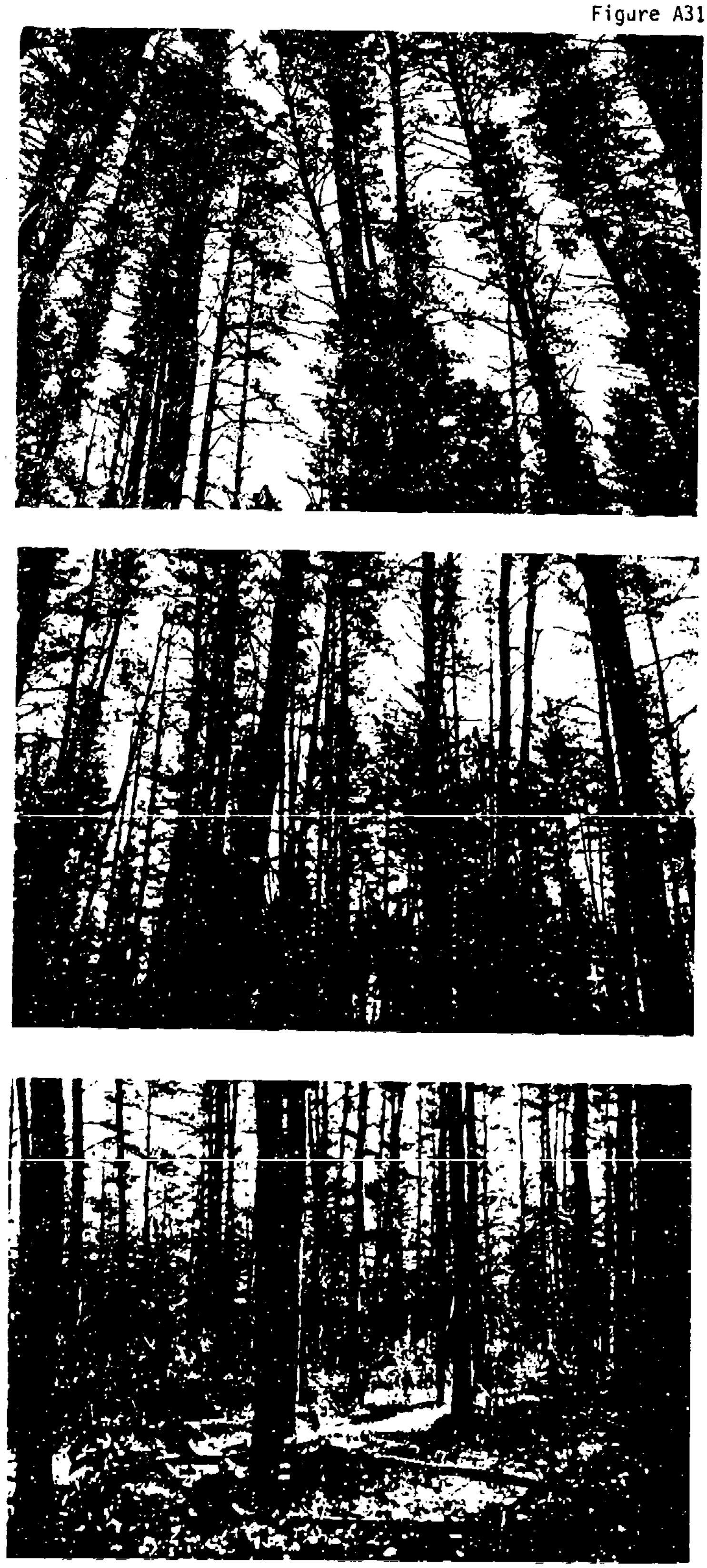
View of the Site
from South

View of the Site
from East

View of the Site
from East

Site JD Reflector #2

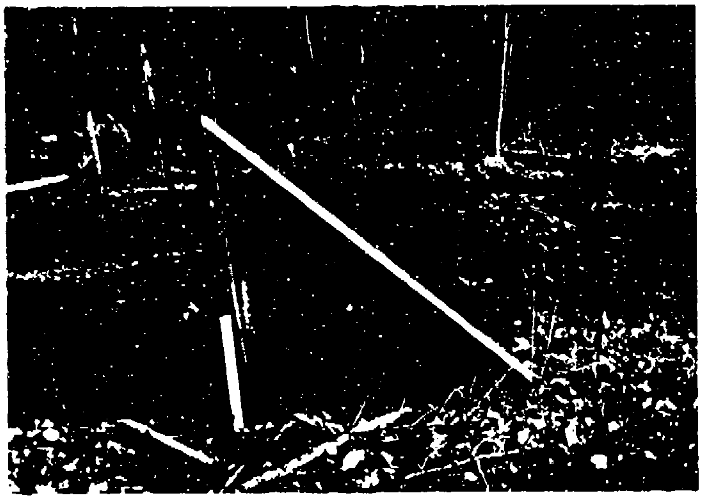
Figure A31.



Views to East from Site

Site JD Reflector #3

Figure A31 concluded.



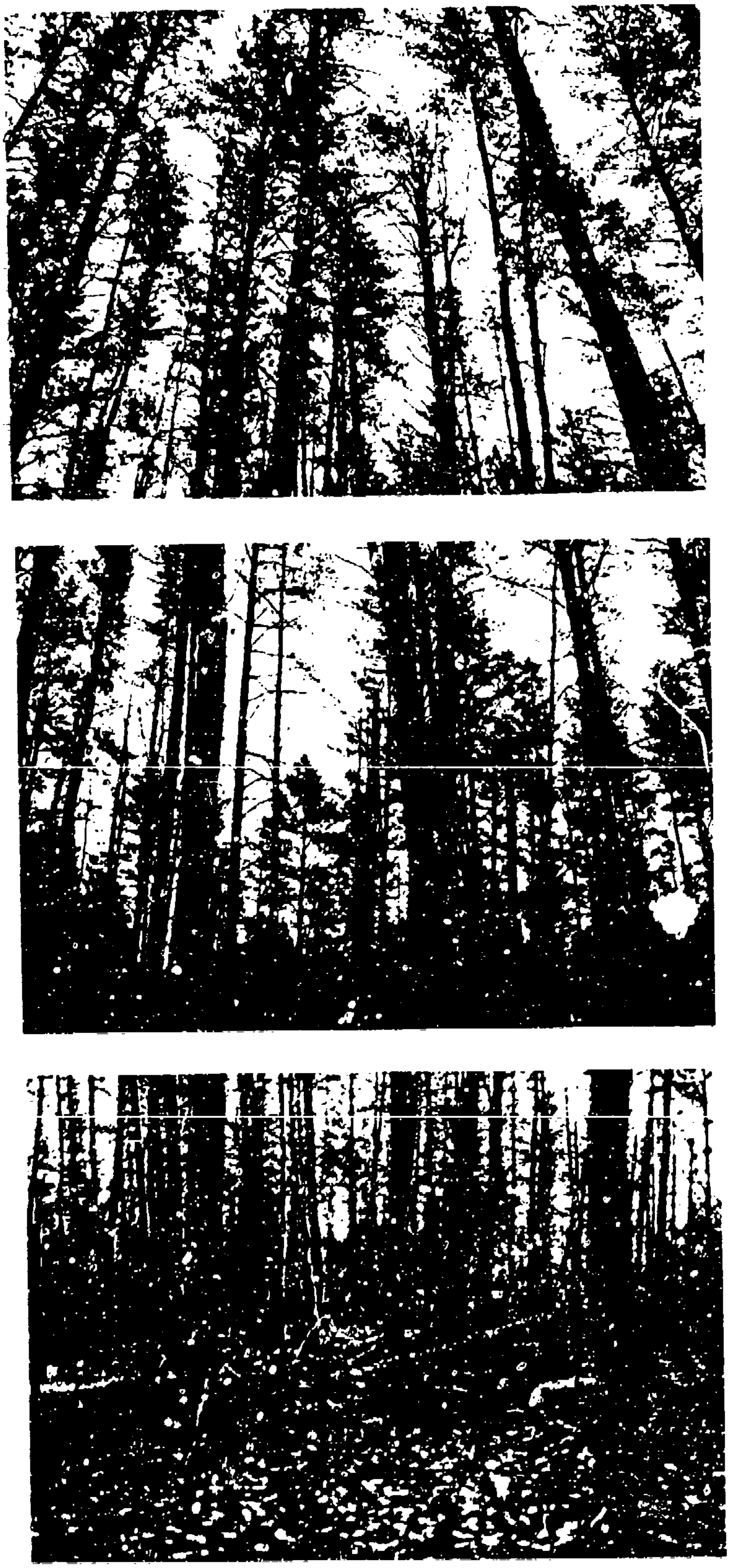
View of the Site
from South

View of the Site
from East

View of the Site
from West

Site JD Reflector #3

Figure A32.



Views to East from Site

Site JD Reflector #4

Figure A32 concluded.

View of the Site
from East

View of the Site
from West

Site JD Reflector #4

Figure A33.

Views to East from Site
Site JD Reflector #5